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A DIGEST OF

INVESTIGATIONS

IN THE

TEACHING OF SCIENCE

IN THE

ELEMENTARY AND SECONDARY SCHOOLS

TEXT BOOKS IN SCIENCE EDUCATION
Edited by S. R. POWERS, Ph. D.
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A Digest of Investigations IN THE Teaching of Science IN THE *Elementary and Secondary Schools*

BY
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Including the Research Investigations Published Prior to 1925

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PREFACE

This monograph is the report of a diligent search of the pedagogical literature of the past twenty years in an endeavor to make available for convenient reference and ready comparison, two types of research studies and investigations in the field of elementary and secondary school science. These two types of studies are those placing major emphasis upon learning and those placing major emphasis upon the curriculum; other types of research in this field e.g. the development or use or tests, are included only when they possess definite values as curricular or learning studies. Articles presenting individual opinions unsupported by objective data, moreover, are without exception omitted.

The criteria of selection of these studies is of necessity more or less subjective, from two points of view, classification under the two types and choice among several similar studies. Under the caption of learning studies, therefore, the author has somewhat arbitrarily grouped those studies presenting objective data upon the way in which children learn the lessons of science. These studies involve the determination of the relative effectiveness of *different* methods, the determination of the strong and weak points of *particular* methods, and the evaluation of certain teaching devices and practices.

Under the caption of curricular studies the author has included all those studies which emphasize the materials which should be considered or stressed in teaching science. These studies involve the determination of aims underlying the teaching of the subject, the determination of the curricular trends in science, and the actual selection of materials

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for inclusion and emphasis in the curriculum. Curricular studies, therefore, include questionary studies, analyses of text-books, vocabulary studies, analyses of magazines and newspapers, and committee reports.

The attempt to classify the investigations as curricular and learning studies reveals a number which might be termed "borderline cases." These are essentially of a psychological nature; they present more or less objective data upon the way in which individuals learn, but their chief values consist of the light they throw upon the way in which the *course* or the *curriculum* should be constructed in order to assure optimal learning values, or upon the subject matter which should be included in the curriculum. Such studies, that of Briggs, Mau, or Finley, for example, do not definitely fit into either of the two types mentioned, but they are not sufficiently different to warrant the making of a third distinct classification. Consequently they are placed in the curricular studies.

The book represents an endeavor to include the learning studies in elementary and secondary school science published before 1925;[1] but no attempt has been made to include

[1] No digest is included of the one-page abstract of the study by Fred G. Anibal, "Investigation of Demonstration versus Laboratory as a Method of Teaching Natural Science," *Addresses and Proceedings of the National Educational Association*, LXII (1924), 771.

Three other published learning studies, performed with university, college, or normal school students are outside the scope of this book:

H. B. Lemon, "The Use of Motion Pictures in Physics Teaching," *School Science and Mathematics*, XXII (1922), 254.

W. G. Bowers, "The Advantages of Laboratory Work in the Study of Elementary Chemistry," *Journal of Chemical Education*, I (1924), 207.

W. G. Bowers, "The Importance of the Laboratory Work as Compared with Text-book Work in the Study of Chemistry," *School Science and Mathematics*, XXIV (1924), 601.

all of the curricular studies. Because of the great number of these studies, this report places its stress mainly upon the investigations published during the period from 1920 to 1925, and presents only such researches published before 1920 as seem in the author's judgment to give data of more or less permanent value.

Digests of 70 different learning and curricular studies compose the body of the book. The form of the digest of each article is that adopted by the Department of Superintendence, N. E. A., in its *Third Yearbook:* A brief statement of the *Problem;* a description of the *Method* or technique used in obtaining the data; and a detailed list of the *Findings*, including usually conclusions and occasionally recommendations. Separate lists of *Conclusions* and *Recommendations* are given only when the investigator has summarized the results of the investigation, or of several separate investigations or units of an investigation.

In stating the *Problem* the author has followed as closely as possible the investigator's wording, but has reserved the use of quotation marks here for emphasis, to call attention to especially important or significant wording by the investigator.

In the *Method* the author has tried to indicate briefly but completely all of the various steps in the technique which bear upon educational experimentation or which pertain to the teaching of science as reported in the original article. Other materials, which are found in some of the published reports of these studies, are omitted from the digests. All but the occasional advanced graduate student will find these digests sufficiently detailed; but such a student, interested in the intricacies of technique in such elaborate investigations as those of Webb, Powers, Beau-

champ, and others, will find only the original report of the investigation adequate for his purpose.

In reporting the *Findings*, *Conclusions*, and *Recommendations* the author has quoted freely; the statements which are not quoted, moreover, give only the *investigators'* interpretations of the data. Significant tables and many complete course outlines are included.

The arrangement of these studies is chronological with respect to the order of their first publication. This arrangement enables the student to follow the historical development of research in the field represented, to note improvement and progress in the development of research technique, and to trace various research tendencies and movements. For the convenience of the busy teacher, various other groupings, by method, by technique, by subject, etc., appear in the *Index*.

Separate investigations contained in a single published report, e.g. in Hunter's learning study and in several of the doctors' theses, are described as separate studies whenever such practice has seemed desirable for the sake of greater simplicity and clearness.

The book should prove a valuable part of the professional equipment of the following groups:

1. All heads of departments of science and all teachers of science in elementary and secondary schools, who wish to improve their teaching practice and their organization of course materials by utilizing the results of previous researches in the field, but who may lack the time or the library facilities for searching out these materials for themselves. (The task of locating all of these studies, moreover, is a difficult one because already several of the reports are out of print.)

2. Supervisors of science, principals, and superintendents who may wish to avail themselves of this convenient means of quickly obtaining a serviceable knowledge of the various studies, as a help in more effectively guiding and directing class-room practice.

The book can be used as a *text-book* by the following groups:

1. Teachers in universities, colleges, and normal schools, who are engaged in training teachers of science.

2. Graduate students in all branches of elementary and secondary education, who are interested in problems of research and in the methods employed therein.

3. Teachers in universities, colleges, and normal schools who are conducting advanced courses and seminars for the purpose of training graduate students to do research.

The special section of *Problems and Exercises* should increase the value and usefulness of the book as a *text-book* by focusing attention upon significant aspects of the various studies.

If the value of this book, as indicated by its reception, proves sufficient, it is the author's and the publisher's purpose to publish from time to time other volumes bringing the work up to date. It is hoped that in a second volume it will be possible to include and thus make generally available, digests of valuable unpublished learning and curricular studies, a considerable number of which are doubtless to be found in the educational libraries of the great universities. The second volume will also include any omitted studies which in the opinions of those whom this book is intended to serve, this first volume should have included.

FRANCIS D. CURTIS.

ANN ARBOR, MICHIGAN,
June, 1926.

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PART I

Problems and Exercises Based Upon the Learning and the Curricular Studies

A Digest of Investigations in the Teaching of Science in the Elementary and Secondary Schools

GENERAL EXPLANATION

The following questions and exercises based upon the various studies included in this book are of the sort which the author has found to be helpful to students interested in studying various practices and techniques in educational research, particularly in the field of the teaching of science. The few questions and exercises here selected from the many which might be formulated upon these studies are intended to focus attention specifically upon the essentials of technique employed; and to stimulate analyses of the studies for the purpose of discovering and evaluating their strong and weak points. All are intended to be *impersonal* and *constructive:* To aid the student in gaining a thorough comprehension and knowledge of the best practice in the past as exemplified by the work of the leaders in this field, as a means of improving practice in the future; to train him to judge and appraise reports of researches critically, rather than to accept the investigator's technique and findings without question; and to enable him to proceed more intelligently and confidently in his own investigations.

The *General Questions* should prove valuable in affording an integration of the knowledge gained from the separate analyses, and should thus provide a surer means of gaining a thorough mastery of the whole field presented. The student, therefore, should postpone a consideration of these *General Questions* until he has finished his study of the questions upon the individual investigations.

The values derived from solving these problems will largely depend upon the detail and care with which the answers are worked out. The student should therefore *think each question and exercise through;* he should make his answer always as *specific* and *definite* as possible, and should be able to *defend* his *judgment in every case.* He should take especial care that such suggestions as he may make for the improvement of various techniques are both *practical* and *practicable* in the light of conditions as they actually exist.

References which have been found helpful in this kind of work are suggested here and there.

PROBLEMS AND EXERCISES ON THE LEARNING STUDIES

Study No. 1L.—(1) Does the investigator employ sound statistical technique in securing the equivalent groups?[1] (2) List specific evidences of scientific technique[2] in this

[1] William A. McCall, *How to Experiment in Education* (New York: The Macmillan Co., 1923), II, III, IV.

[2] The following are some of the criteria of sound statistical technique: Does the investigator take care to state the problem clearly and concisely, and to delimit it carefully; to describe the experimental factor precisely; to eliminate irrelevant factors in the experiment; to secure appropriateness of the subjects to the experimental factor; to secure representativeness of subjects; to employ sound technique in pairing subjects; to secure suitable controls; to assure adequacy of check

study. (3) Does Finding 3 signify skewed distributions of marks?[1]

Study No. 2L.—(1) Is this experiment a "one-group," an "equivalent-groups," or a "rotation" experiment?[2] Does the technique described in the first paragraph satisfy the conditions for that particular type of experimental method? (2) Does the selection of subjects for this experiment afford a representative teaching situation? Does this factor of selection increase or diminish the influence of the Findings upon teaching practice? (3) To what extent does each method of teaching used in the experiment represent a typical class-room procedure, and hence to what extent are conclusions based upon data secured from using these various methods in the experiment worthy of consideration by the teacher in improving her teaching methods? (4) Compare Finding 5 with the Findings of Study No. 4L. (5) How do Findings 13 and 14 agree with the results of more recent research upon psychological factors in the teaching situation?[3] (6) What influence upon teaching practice should Finding 17 exert?

Study No. 3L.—(1) Justify your classification of this investigation with respect to experimental method.[4] (2) Does the investigator employ sound statistical technique

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experiments; to employ objective tests; to acknowledge shortcomings of the technique; to eliminate personal biases; to secure a logical and orderly presentation of data; to employ a uniform treatment of data; to make logical deductions from the data; to employ caution in drawing conclusions from the data; etc.?

[1] Arthur S. Otis, *Statistical Method in Educational Measurement* (Yonkers, N. Y.: World Book Co., 1925), VI.

[2] William A. McCall, *How to Experiment in Education* (New York: The Macmillan Co., 1923), II, III, IV.

[3] Arthur I. Gates, *Psychology for Students of Education* (New York: The Macmillan Co., 1924), pp. 285–288, and XVI.

[4] McCall, *op. cit.*, II and III.

with respect to the control?[1] (3) List modifications of technique which might produce more convincing data. (4) What advantages are secured from random sampling?[2] (5) What is the psychology underlying the practice described in the sentence, "To eliminate as far as possible the element of memory . . ."?

Study No. 4L.—(1) What is meant by the "point basis of scoring"? What advantages, if any, does it possess over other marking practices? (2) Outline briefly but definitely one or more techniques for using marks given by 10 scorers. (3) Are these Findings in harmony with present representative class-room practice with respect to the teaching of science, especially biology?

Study No. 5L.—(1) Justify your opinion of the soundness of the statement, "Any conclusions drawn . . ." (2) Analyze the Findings sentence by sentence. Justify your opinion of the soundness of each as an *objective* conclusion based upon the numerical data given.

Study No. 6L.—(1) Has the investigator employed sound statistical technique in securing equivalent groups?[1] If not, suggest improvements of the technique. (2) Does the investigator employ sound statistical technique in standardizing the lessons?[3] If not, suggest improvement in technique. (3) Is the marking plan sufficiently objective? If not, suggest improvements.

Study No. 7L.—(1) Is the method here used in selecting the experiments and marking the reports sufficiently objective? If not, suggest improvements. (2) Compare the summary and suggestions with the summary of Study No. 19L, for specific agreements or differences.

[1] McCall, *loc cit.*
[2] *Ibid.*, pp. 38–40.
[3] *Ibid.*, pp. 130 ff.

Study No. 8L.—(1) Has the investigator employed sound statistical technique in selecting the equivalent groups?[1] If not, suggest improvements of the technique. (2) Compare the Findings with those of Studies No. 7L and 19L, for specific agreements or disagreements.

Study No. 9L.—(1) What was the function of the "control group"? (2) State definitely the strong and weak points of the method here used for standardizing the "minimum possibilities" of the play units. (3) Outline briefly but definitely a technique by which the material might be "graded for difficulty." (4) Justify your selection of specific strong and weak points in the method here used for roughly standardizing the "visual and practical tests."[2] (5) Suggest a technique for obtaining an *objective* basis for the statement at the end of Finding 4.

Study No. 10L.—(1) Compare the technique of this experiment with that of Study No. 2L for *relative* differences and superiorities. (2) See foot-note at the end of Unit I. Was equating of the groups necessary with the technique used?[1] (3) In Study No. 2L, Mayman says, "The fact that the Book Method was not tried with actual text-books is a serious criticism on my investigation." In Study No. 10L, Hunter mentions his own use of an actual text-book to avoid this criticism. Justify your opinion concerning the seriousness of this criticism. (4) Which of the three types of experimental method[1] would be best suited to the investigation in Unit II? Outline briefly but definitely and completely the technique for carrying out this investigation using the experimental method selected.

Study No. 11L.—(1) Which of the three types of experimental methods is here used?[1]

[1] *Ibid.*, II and III.

[2] *Ibid.*, pp. 130 ff.

Study No. 12L.—(1) Which type of experimental method is here used?[1] (2) Suggest a way to overcome the difficulty suggested in ". . . all attempts . . . ," General Conclusion 4. (3) Compare General Conclusion 5 with the second paragraph of Finding 6, Study No. 23L. Justify your opinion of the soundness of both these Findings by the two experimenters. (4) List evidences of scientific technique in these last three investigations.[2]

Study No. 13L.—(1) Has the investigator used sound statistical technique in securing her "basis of comparison of ability"? (2) Justify your opinion of the significance or value of Finding 3, with respect to teaching practice.

Study No. 14L.—(1) What is the E. F. (experimental factor) in this investigation?[1] (2) Outline briefly but definitely the technique you would use in standardizing a test such as the one here described.[3] (3) What is the significance of Finding 3 with respect to laboratory teaching practice?

Study No. 15L.—(1) Compare this study carefully with Study No. 18L for similarities and differences of technique, findings, etc. (2) Outline briefly but definitely a technique by which the "minimum essentials" of the course here discussed might be determined. (3) List definitely evidences in this study, of tests used as *teaching* devices.

Study No. 16L.—(1) Does the investigator use sound statistical technique in securing equivalence in groups?[1] If not, suggest how the technique might be improved. (2) Justify your opinion of the relative significance and value of this learning study and the questionary study mentioned in the foot-note .

[1] McCall, *op. cit.*, II and III.

[2] For criteria of scientific technique, see foot-note, page 4.

[3] McCall, *op. cit.*, pp. 130 ff.

Study No. 17L.—(1) In an equivalent groups experiment, is the equating of groups by *averages* statistically sound?[1] (2) Make a detailed comparison of this experiment and Study No 20L. (3) Note the sentence on page 74, "The latter were informed . . . " Is the pupil interest secured by the practice here described extrinsic or intrinsic?[2] Justify your opinion of the soundness of the statement on page 74, ". . . this practice prevented testing results . . ." (5) To determine whether the experimenter is correct in his statements in the last paragraph of the Method, outline briefly but definitely a scheme for comparing the data pertaining to the various methods. (6) Justify your opinion of the soundness of Finding 6 on the basis of the reason stated.

Study No. 18L.—(1) Does the experimenter employ sound statistical technique[3] in equating the groups? (2) List specific evidences of scientific technique[4] in this experiment. (3) Outline briefly but definitely a technique for carrying out this experiment by the "one-group" method.[3] List the advantages of the method here used by the experimenter over the "one-group" method for this experiment. (4) Justify your selection of the most important contribution of this experiment from the standpoint of improving teaching practice.

Study No. 19L.—(1) What experimental method or methods are here used?[3] (2) What phase of learning is tested in this experiment which is not tested in the other similar studies? (See Index.) (3) List several "principles utilized in making standardized tests."[5] (4) Why are the

[1] *Ibid.*, pp. 45 ff.

[2] John Dewey, *Interest and Effort in Education* (Boston; Houghton Mifflin Co., 1913).

[3] McCall, *op. cit.*, II and III.

[4] For criteria of scientific technique, see foot-note, page 4.

[5] McCall, *op. cit.*, pp. 130 ff.

small advantages of the demonstration method "very significant"?

Study No. 20L.—(1) Does the experimenter employ sound statistical technique in selecting the groups?[1] If not, suggest improvements of technique. (2) What bearing, if any, does the foot-note have upon the Findings? Upon the General Conclusions? (3) List points of relative superiority in this study and in Study No. 15L.

Study No. 21L.—(1) In which unit will the technique employed lead to more significant and valuable conclusions?

Study No. 22L.—(1) Note that the experimenter uses the term "project teaching," instead of the usual term, "project-method." Justify your opinion regarding whether the project "method" is really a method? (2) Note the experimenter's distinction between "pupil's projects" and "assigned problems." Justify your opinion regarding whether his distinction between a project and a problem is valid. (3) List points of similarity between the techniques of this study and Study No. 13L. (4) List definite reasons for considering sound or unsound the bases of comparing the results of the project learning and the non-project learning. (5) What is meant by "reliability" and "validity" of a test?[2] (6) List strong and weak points in the plan for weighting and scoring the test exercises.[1] (7) Does the experimenter employ sound statistical technique in getting the "mean growth ratio"?

Study No. 23L.—(1) List specific evidences of scientific technique in this study.[3] (2) Outline briefly but definitely a technique which might enable one to secure data of

[1] McCall, *op. cit.*, II and III.

[2] Otis, *op. cit.*, XX.

[3] For criteria of scientific technique, see foot-note, page 4.

value in solving some of the problems suggested in Finding 6.

Study No. 24L.—(1) Does the experimenter employ a sound statistical method of equating the groups?[1] If not, suggest improvements in technique. (2) What are the relative merits of the two methods of scoring? (3) Compare the Findings with those of Unit II, Study No. 18L, for points of agreement or disagreement.

Study No. 25L.—(1) What is a Brightness Quotient? Is it the same as an "I. Q."? (2) What is the statistical theory underlying the practice of pairing on the basis of Brightness Quotient when the experimental results are measured in *achievement?* (3) What pedagogical significance, if any, is there in the conclusion that "extensive reading probably tends to increase the variability . . ."? (4) In which of the three units does the experimenter employ the soundest statistical technique in pairing?[1] (5) Justify your opinion of the value, in Unit III, of the "check upon the results . . ." (6) What probable effect upon the results was produced by giving the initial test 10 days after the beginning of the experiment?

Study No. 26L.—(1) Does the experimenter employ sound statistical technique in securing a list of scientific attitudes? If not, suggest improvements in technique. (2) What light, if any, was thrown on the problem of training in scientific attitudes, by the check experiment with the graduate students? (3) What is the statistical significance of the statement in Finding 4, Unit I, ". . . because of the small number of cases . . ."? (4) In Unit II, does the experimenter employ sound statistical technique in pairing?[1] If not, suggest improvements in technique.

[1] McCall, *op. cit.*, II and III.

PROBLEMS AND EXERCISES ON THE CURRICULAR STUDIES

Study No. 1C.—(1) Justify your opinion of the adequacies or inadequacies of the technique with respect to the problem as stated. (2) Suggest a plan or plans by which the investigator might have secured more complete and definite information of the kind wanted in Question 1, Set I, and Questions 1, 2, and 3, Set III. (3) Compare Finding 11, of Set II with Finding 13 of Unit I, Study No. 12C. Suggest a plan for carrying out in the grades, the suggestion in Finding 11.

Study No. 2C.—(1) Justify your opinion of the adequacies or inadequacies of the technique with respect to the problem as stated. (2) Analyze the conclusions in the General Summary. To what extent are they justified in the light of the data here presented? (3) What are the relative strong and weak points of Units I and II? (4) In his summary of this study in the *Third Yearbook*, Department of Superintendence, N. E. A., Downing says, "It was feared the results [of Unit I] were hardly fair, for the choice lay between toy and non-toy. Hence the experiment was repeated with materials that were equally active." Were they?

Study No. 3C.—(1) Justify your opinion of the soundness of the investigator's statement in the Method, "It was thought . . ." (2) What was probably the investigator's purpose in showing that the average ages of the boys and girls were practically equal?

Study No. 4C.—(1) Define "an average school under average conditions." Justify your definition. (2) What is the distinction between a representative sampling and a selected sampling? (3) Justify your opinion of the soundness of using a *selected* list of replies as a source of data on "*average*" conditions.

Study No. 5C.—(1) What is meant in Finding 1, by a "scientific attitude of mind"?[1] (2) State a reason or reasons to account for the first statement in Finding 7.

Studies No. 6C, 7C, and 8C.—(1) List the strong and weak points of each of these three similar studies from the standpoint of scientific technique.[2] (2) Does the investigator employ sound statistical technique with respect to the check described in the last paragraph of the Method of Study No. 6C?

Study No. 9C.—(1) In aim *B*, what is meant by "a scientific method of procedure"?[3] (2) Is the scientific method the same as the scientific attitudes?[1]

Study No. 10C.—(1) List specific values and limitations of this type of study from the standpoint of its influence upon the selection of subject matter units for courses in science. (See also, Study No. 28C.)

Study No. 11C.—(1) List the strong and weak points of the three phases of this investigation from the standpoint of their effectiveness and adequacy for securing complete data upon the problem as stated. (2) Justify your opinion of the objectiveness of the criteria for the selection of course elements from the data.

Study No. 12C.—(1) What was the investigator's probable reason for securing the questions from the children in the manner described? (2) What light were the check experiments in both units expected to throw upon the genuineness of the children's interests as revealed by their

[1] Francis D. Curtis, *Some Values Derived from Extensive Reading of General Science*, (New York: Teachers College, Columbia University, Contributions to Education No. 163, 1925), pp. 41–50.

[2] For criteria of scientific technique, see foot-note 2, page 4.

[3] W. L. Eikenberry, *The Teaching of General Science* (Chicago: The University of Chicago Press, 1922), pp. 76–77.

questions? (3) Why in Unit II were the objects "presented to the classes in varying orders"?

Study No. 13C.—(1) Outline briefly but definitely one or more techniques which the committee could have used in constructing the outline.

Study No. 14C.—(1) Justify your selection of specific points from the Findings which should exert a practical influence upon the teaching of sex hygiene. (2) Outline briefly but definitely other types of studies which might yield data upon the selection and presentation of course materials in sex hygiene. (See Study No. 19C.)

Study No. 15C.—(1) Analyze the study for specific instances of scientific technique.[1] (2) What is a coefficient of correlation? How is it found and used?[2] (3) Is the investigator's reasoning sound in regard to the suitability of a topic as determined by its "acceptability factor"?

Study No. 16C.—(1) In the Method of Unit I, why should "special effort be made to avoid questions which could be answered . . ."? (2) In the Method of Unit I, what is meant by a "fair sampling"? (3) What is a "normal distribution curve"?[3] What does its "close approximation" in Unit I signify? (4) Make a list of definite instances of the investigator's use of a scientific technique in this study. (5) Compare the three measures of central tendency, the mean, the median, and the mode.[4] (6) Outline a curriculum of science for the upper grades using the topics in Table IV which are in harmony with the investigator's findings with respect to materials appropriate to the fifth, sixth, seventh, and eighth grades. (7) What specific

[1] For criteria of scientific technique, see foot-note 2, page 4.
[2] Otis, *op. cit.*, VI.
[3] *Ibid.*, XV.
[4] *Ibid.*, II.

agreement is there between Finding 6, Unit III, and the Findings of Study No. 21C.

Study No. 17C.—(1) Compare Finding 2 with the Findings in Study No. 15C. (2) Check the 89 topics with the "Outline of Standardized Course," to ascertain how many of the topics are definitely placed in the outline.

Study No. 18C.—(1) Give one or more specific reasons to account for the facts in Finding 11. (2) What mutual significance, if any, have the statement in Finding 11 and the choice of animal used in Unit I, of Study No. 12C. (3) How do you account for the fact that "absurd questions were surprisingly few"?

Study No. 19C.—(1) List other groups besides the "representative principals," whose reactions upon the merits of the "aims, content, and methods recommended," it would be desirable to secure.

Study No. 20C.—(1) In the light of these Findings, make several definite recommendations with respect to curricular elements or teaching practice in science in the elementary and the high school. (2) Suggest one or more reasons which might account for Finding 1.

Study No. 21C.—(1) What points in common have the investigator's "hierarchy of questions" with the steps of the scientific method?[1] With the scientific attitudes?[2] (2) Select from the Findings a number of suggestions for the improvement of method in the teaching of science. (3) Using appropriate subject matter construct one or more class exercises intended to train the pupils to realize the higher steps in the hierarchy.

Study No. 22C.—(1) Is 86 per cent a relatively high or low percentage of returns from a questionary study? (2)

[1] Eikenberry, *loc. cit.*

[2] Curtis, *loc. cit.*

List the relatively strong and weak points of the various practices described in Finding 7. (3) Suggest criteria other than those given in Finding 9, by which "any given course [in biology] could be evaluated." List types of goals in terms of which a course in biology may be evaluated.

Study No. 23C.—(1) State a definite reason or reasons for agreeing or disagreeing with the statement in Finding 1. (2) State definite reasons why you accept or reject the conclusion in Finding 3. (3) Justify your arguments favoring or opposing standardization of the laboratory course in chemistry. (4) Considering Finding 2 and the "Average Number of Exercises per Manual," determine the basis for the values in the "weight" column. (The investigator in his article clearly explains this point which is omitted in the digest.) (5) Justify your reasons for approving or disapproving of the distribution of experiments among the various topics in accordance with their "weights."

Study No. 24C.—(1) Does the investigator choose a sound "working hypothesis" for his study? (2) Classify as subjective or objective, the sources from which "the kinds of function involved in the answers to each question" were determined. (3) How do the Findings agree with present aims in the teaching of biology? (See Index.) (4) In Finding 8, what is the meaning of "educational values claimed for science"? (5) Outline briefly but definitely a technique for determining the "definite and undoubted usefulness," mentioned in Finding 9. (6) Name some of the "great fundamental interpretive principles of biology."

Study No. 25C.—(1) Describe briefly but definitely other "methods of laboratory procedure" besides that described in Finding 2.

Study No. 26C.—(1) How many of the seven aims in the *Cardinal Principles of Secondary Education* appear in the list

in Finding 3? (2) What statistical procedure would produce a numerical result showing exactly how "striking" the "amount of agreement was" between the rankings mentioned in Finding 4?[1]

Study No. 27C.—(1) List other sources of objective data which might be used in the construction of subject matter tests in biology. Briefly outline a technique for securing the desired data from each source. Compare the relative merits of these sources. (2) Justify your acceptance or rejection of the investigator's definition of an "average course" in biology as implied in the statement of the Problem.

Study No. 28C.—List evidences of scientific technique[2] found in this investigation.

Study No. 29C.—(1) Reconstruct in outline form, from the brief description, the technique followed by the investigator in determining the basic aims given in Finding 1.

Study No. 30C.—(1) Justify your opinion of the value of such a questionary study as the one here mentioned, by which the investigator secured the opinions of pupils regarding the worth of subject matter items.

Study No. 31C.—(1) Cite evidences of scientific technique in this study.[2] (2) Cite specific data from other studies in this book which agree or disagree with the statement in Finding 7, "This differs fundamentally . . ." (3) Give one or more specific illustrations to show how to put into class-room practice the suggestions in Finding 17.

Study No. 32C.—(1) Justify your agreement or disagreement with the "Recommendations." (2) Suggest an explanation or explanations of the facts stated in Finding

[1] Otis, *op. cit.*, pp. 206 ff.

[2] For criteria of scientific technique see footnote 2, page 4.

2. (3) Which, if any, of these Findings agree with Findings in Study No. 44C?

Study No. 33C.—(1) How might one ascertain the most widely used text-book in a subject? Outline one or more techniques. (2) Devise a simple and definite technique for obtaining the "teachers' stress . . . of the relative importance" of topics evaluated in accordance with the investigators' weighting system. (2) How does the opinion expressed in Finding 3, regarding the "basic aims of each teacher's effort" agree with the implied opinion with respect to this same factor in Study No. 27C? (3) State definitely your reason for agreeing or disagreeing with the investigators' statement in Finding 3, "nor should the . . ." (4) Cite from elsewhere in this book an opinion with respect to another subject, similar to that expressed by these investigators in Finding 4, ". . . the backbone . . ."

Study No. 34C.—(1) Outline briefly but specifically one or more techniques for revising and improving a course outline in the light of criticisms and suggestions from teachers who have taught it.

Study No. 35C.—(1) Are the criteria for judging the illustrations adequate for producing reliable and objective data? (2) Outline a technique by which to determine the reliability of judgments based upon these criteria.

Study No. 36C.—(1) What significant differences are there between this revised outline and the tentative one published six months earlier? (See references in the digest, for locating the original published outline.) (2) Outline briefly but definitely a practical and practicable technique by which the original outline might have been revised between the time of the *April* meeting and the date of publication of this outline, so that it might be "as near as

possible in accordance with the thirty thousand criticisms which had been made available."

Study No. 37C.—(1) State definitely what you consider to be the importance and value of this study with respect to curricular construction. (2) Did the intentional selection of high school and college text-books by the same authors increase or diminish the significance of the investigator's findings? (3) Suggest reasons why a comparative study of high school and college courses in chemistry should throw more light upon the problem of overlapping in high school and college than a similar study of any other branch of science.

Study No. 38C.—(1) List several sources from which such a list of activities might be obtained. (2) Compare Recommendations 5 and 6 with the suggestions in the Findings of Study No. 21C.

Study No. 39C.—(1) State one or more ways other than that here used, by which to determine the words in a text-book with which "a child might have difficulty." (2) Justify acceptance or rejection of the investigator's opinions stated in Findings 1, 3, and 6. (3) Outline briefly but definitely a technique which would assist in determining "hard words [in science] which are not apt to be learned from general reading." (4) List further desirable extensions of analyses of scientific vocabularies. (See Study No. 43C.)

Study No. 40C.—(1) Does the investigator employ sound technique for securing adequate data upon the Problem as stated? If not, suggest improvements in the technique. (2) Justify your acceptance or rejection of the investigator's statement in the last sentence of Finding 1. (3) Justify your acceptance or rejection of the investigator's conclusions in Findings 2, 3, and 4.

Study No. 41C.—(1) Make as long a list as you can of specific values of this type of study. (2) In what respects, if in any, does Table XVII in itself indicate that science is growing in popularity with high school pupils as compared with other subjects. (3) To what other factor or factors besides that mentioned in Finding 6, may increase in *number* of pupils taking science be due? (4) Outline a method of setting up an experiment to secure *objective* data confirming or contradicting the teachers' *opinions* expressed in Finding 7.

Study No. 42C.—(1) Formulate definitely the statements of the problems for several curricular studies of the type suggested in Recommendation 1. Outline briefly but definitely the technique or techniques for securing objective data upon one or more of these. (2) Which investigation or investigations in this book shed light upon "what people need to know about science"? Outline one or more other investigations for securing additional data upon this point.

Study No. 43C.—(1) Compare the techniques of this study and Study No. 31C for similarities and differences. (2) List further extensions and desirable refinements of technique of the analyses of science in newspapers. (3) Justify your opinion regarding the objectivity of the data secured from an analysis of newspaper science in accordance with the technique here described. (4) Cite several studies in this book which furnish the basis for judgment upon "general information of a scientific nature [which] the ordinary course in general science might reasonably be expected to furnish." (5) What earlier study or studies in this book furnish the basis for the statement in Finding 3, " . . . to which is devoted much less space . . . "

Study No. 44C.—(1) Compare the techniques of this study and Study No. 32C for similarities and differences. (2)

What limitations in the scope of this study are indicated in Finding 5? (3) Account for Finding 8 in the light of Finding 7. (4) To what extent may the great interest in astronomy, as revealed by the questions of pupils and adults, be accounted for by the fact that model questions about astronomy were included among others in the letter of instructions to pupils. (See Study No. 32C for this letter.) Suggest modifications of the instructions to pupils as given in this study, which in a subsequent similar study would produce data likely to prove or disprove the conclusion in Finding 10, that astronomy is a "life interest."

GENERAL PROBLEMS AND EXERCISES

1. (*a*) Make a historical study of the investigations to note specifically (a) the various kinds of investigations in their relative order of appearance; (b) tendencies toward greater scope or toward greater refinement of technique with respect to each particular kind of investigation; (c) changes in technique due to the introduction of new-type achievement and standardized tests.

2. (1) List definite reasons for approving or condemning in the reports of investigations the usual practice of basing conclusions upon averages.

3. (1) Make a list of criteria for judging the values of published reports of the techniques and findings of research investigations. Keep in mind the various individuals, students and makers of text-books, of syllabi, of tests, etc., whom the reports must serve. (2) Examine several research reports to note whether they satisfy your criteria of good reports.

4. (1) State definitely a number of strong and weak points, e.g. with respect to scope, technique, etc., of the various kinds of investigations of *interests* included in this

book. (2) Outline as definitely as possible a technique by which the Findings of all the various studies of *interests* (See Index), might be used in determining some of the minimum subject matter essentials in a curriculum for science in (a) the primary grades; (b) the intermediate grades; (c) the junior high school; and (d) the ninth grade of the four-year senior high school. (Intelligent discussion of minimum essentials must be based upon an answer to this question, "For what future needs of what types of individuals are the course elements to furnish essential knowledges and skills?") (3) Outline as definitely as possible a technique for combining the data from *all* sources for the purpose of securing a more valid list of minimum essentials of subject matter.

5. Review the questionary studies. (See Index.) (1) Make a definite list of specific limitations of the questionary study as a type of research. (2) Name any kinds of information which could be secured only, or most effectively, by the use of the questionary. (3) Make a careful list of criteria of a good questionary study. (4) Make a list of directions for the administration of a questionary investigation.

6. Compare all the lists of aims for some one course or courses. (See Index.) (1) Outline briefly but definitely a technique by which to combine several lists of aims to determine a limited list of basic aims. (2) State definite values and limitations of such a list.

7. (1) Make a list of values and limitations of course outlines and syllabi prepared by committees. (See Index.) (2) Justify your opinion upon the question of whether such reports from authoritative committees tend as a rule to exert more or less influence upon practice generally than their probable merits warrant. (3) Outline briefly and

definitely a technique by which several committee reports on course materials might be combined to throw light upon some of the minimum essentials of the course.

8. Make a careful comparative analysis of the various experiments upon teaching methods. (See Index.) (1) Justify your opinion regarding whether the investigators used mutually comparable techniques in their investigations of the same methods for the same course. (2) List relative superiorities of technique, and agreements and disagreements in the Findings for two or more studies of the same teaching method for the same subject. (3) Summarize general conclusions which, from a consideration of all the investigations of teaching methods, seem justified with respect to the relative values of the various methods. Compare your summary with that of Downing;[1] consult also Laird.[2]

9. (1) Make a definite list of the strong and weak points of the studies of analyses of text-books. (See Index.) List further extensions of this kind of study which are desirable because of possible light which they might shed upon subject matter materials now in use.

10. (1) Study the form and make-up of the various outlines and tables. In what specific respects do they individually, or as a whole, measure up to or fall short of good form in tables?[3]

11. (1) List the investigations of both groups, the learning and the curricular studies, in three classes: (a) those

[1] Elliot R. Downing, "A Comparison of the Lecture Demonstration and the Laboratory Methods of Instruction in Science," *The School Review*, XXXIII (1925), 688–697.

[2] D. A. Laird, "A Report of Students' Attitude toward Laboratory Courses." *School and Society*, XIX, 589–592.

[3] *A Manual of Style* (Chicago: The University of Chicago Press, 1925), pp. 138–150.

which present sufficient evidence of statistical technique[1] that their Findings are worthy of consideration in modifying present class-room practice and materials; (b) those which present some evidences of sound statistical technique, but not enough to warrant modification of current practice in accordance with their Findings; (c) those which present findings which because of the investigator's failure to employ scientific technique are valueless, or practically valueless. (2) List from this book any problems the solutions of which have been so complete and convincing that no further investigations of these same problems seem necessary.

12. An eminent authority states that one index of the value of an educator is the number of worthwhile unsolved educational problems which he can formulate. (1) List such practical and practicable problems as grow out of the various studies in this book, or as are suggested by them. Carefully delimit each problem in a definite and concise statement; indicate briefly an appropriate technique for its solution.

[1] For criteria of scientific technique, see foot-note, page 4.

PART II

The Learning Studies

STUDY NO. 1L

An Experiment on Methods of Teaching Zoology

By J. P. Gilbert*

Problem.—To contribute some definite and tangible data for the solution of the problem of the relative merits of two methods of approach to the study of zoology, the applied science (the economic) approach, and the pure-science (the cultural and disciplinary) approach, with respect (1) to the assimilation of zoological knowledge; (2) to ability in experimentation and interpretation; (3) to pupil interest and its results.

Method.—A class of beginners in zoology in the Academy of the University of Illinois, during the first semester of 1909–10 were divided into two groups of respectively 15 boys and 2 girls, and 13 boys and 2 girls, equated approximately with respect to sex, age, fathers' occupations, pupils' home occupations, and pupils' intended occupations. Both groups were under the same teacher and used the same laboratory and apparatus, text-books, and laboratory guides. Both classes covered the same subject matter and were given the same tests. No selection for either section was attempted; the pupils were not informed of the experiment either upon registration or during the semester and

* *The Journal of Educational Psychology*, June, 1910. Vol. I, pp. 321–332. A digest of this investigation is given under the title, "An Experiment in the Teaching of Biology," *The Nature Study Review*, March, 1910. Vol. VI, pp. 78–80.

"could not therefore choose one section or another because of individual preference."

Both groups studied structure, adaptation, distribution, etc., of animals, but group A (the cultural and disciplinary group) emphasized adaptation of species for survival, while group B (the economic group) emphasized adaptations from the standpoint of economic importance, whether these rendered the species helpful or injurious to crops, etc.

The results with respect to the amount of zoological knowledge assimilated were tested by a comprehensive and thorough written examination of identical questions to both groups. Every effort was made to avoid the economic element so that group A would be at no disadvantage. The examination papers were numbered and the marks were recorded before the names of the pupils holding the numbers became known to the instructor.

How the ability of the pupils to set up experiments and interpret phenomena was tested is best explained by an example:

A supply table was provided with all the necessary containers and apparatus for the transfer of materials; with thermometers, food materials, etc., for the experiment: Mosquito larvae of uniform age and size were placed on the table and the classes were directed to determine by experiment the effect of abundance and scarcity of food-supply upon the rapidity of growth and development of mosquito larvae. The individual students were then required to write out detailed accounts of the steps to be taken and to present this for approval. This precaution prevented the possibility of students' getting suggestions by seeing other students at work on the same problem. Defects such as [failing] to specify that containers in the experiment must be placed under the same temperature and light conditions were checked against the student and he was required to make a second report.

To stimulate interest, readings from Burroughs, the Peckhams, Darwin, Huxley, Wallace, De Vries, Jordan,

Kellogg, etc., were assigned to group A, and readings from numerous bulletins from the Department of Agriculture at Washington, and from the state experimental station were assigned to group B. "Records of voluntary readings by the two sections were somewhat vitiated because the books were frequently in use by other departments of the University."

Findings. (1) "After calculating the probable error in all the data obtained, a very slight advantage appears in favor of the economic approach," though "this advantage is too small to warrant any final conclusions upon a single trial of the experiment . . ."

2. Comparisons of the percentages of pupils in both groups making above 85 per cent, from 75 to 85 per cent, and from 70 to 75 per cent likewise ". . . seems to point to a rather clear advantage" for group B.

3. Frequency curves plotted both for the examination marks and for pupils averaging over 85 per cent show a uniform advancement of "stations" of the various groups of experiment group B as compared with analogous groups of experiment group A, while the frequency curves for marks in other subjects show the inverse relation.

4. With respect to the ability to set up experiments and interpret phenomena, of group A, 35 per cent reported correctly on the first trial and 47 per cent more on the second; of group B, 60 per cent reported correctly on the first trial and 33 per cent more on the second. "This gives an advantage of first reports in favor of the economic section."

5. While the investigator does not care to present the figures and mathematical findings until he has better control of the factors involved, he states that interest, both in the regular class work and in discussions and outside work seemed greater in the economic section; it was here, more-

over, that the results seemed to be most favorable to the economic approach.

STUDY NO. 2L

An Experimental Investigation of the Book Method, Lecture Method, and Experimental Method of Teaching Elementary Science in Elementary Schools

By Jacob Edward Mayman*

Problem.—To determine which one or more of these four methods, the *book method*, the *lecture method*, the *experiment method*, and the *experiment-note-book (combination) method* is best from the point of view of efficiency, economy, interest, permanency, etc., for the purpose of teaching of elementary science (physics) to elementary pupils.

Method.—The subjects of this experiment were about 500 Jewish boys, comprising 14 seventh- and eighth-year classes ranging from 24 to 45 pupils, in a public elementary school of New York City. These boys ranged from 11 to 17½ years old; the average age was 13 years, 8 months, with wide individual variation between classes. One-third were foreign born, and the environment of all was generally poor. The average intelligence, as far as physics was concerned, "was about the same in all classes."

Each lesson was taught to each experiment class of the same grade by a different method from that used with other classes of the same grade. The subject matter for the entire experiment was taken from physics.

With the *book method* the experimenter wrote the lesson himself, or he copied the material from an elementary

* Doctor's thesis. New York: New York City Bureau of Educational Research, 1912.

science book written expressly for elementary school use; he added diagrams where he thought them necessary and mimeographed the lesson sheets.

With the *lecture method*, the experimenter told the substance of the *book method* lesson, holding rigidly to content and material but using gestures and drawing on the blackboard the diagrams used in the *book method*.

With the *experimental method* the same material was imparted by means of experimental demonstrations, except that when less subject matter was covered than with the *book* and *lecture methods*, the remaining facts were brought out by question, suggestion, or statement; a description of the apparatus and an informal statement of the aim of the lesson were given. Talking during the demonstration was limited to a word here and there, so as not to combine the experiment with an informal lecture. The boys were allowed to draw their own conclusions and in rare instances one or more boys summarized the facts of the lesson.

In the *experiment-note-book method* (*combination*) the pupils used their note-books in addition to the experiment as done in the *experiment method*. "After the experiment one or more boys in turn described the experiment, read the experiment card, and answered the questions thereon." Rough sketches of apparatus were made on scraps of paper at home; the Object, Apparatus, and Operation were copied verbatim from card to note-books; questions were answered and diagrams carefully drawn.

The investigation, which extended over the spring and fall terms of 1911, included, all told, 30 experiments,[1] of

[1] The experimenter considered a complete experiment to consist of a comparison of the results obtained by teaching a certain unit of subject matter to several classes, each by a different method, but all on the *same* day.

which the *combination method* figured in only 5. During the fall term 8 of the experiments of the spring term were repeated for purposes of verification.

Uniform tests of the essay type testing memory and power were given upon the completion of a series of lessons. Twelve experiments were interval experiments, i.e., the test was repeated at a stated interval varying from 6 days to 56 days, but approximately uniform for all classes for each respective comparison of methods. No test papers were scored until the entire experiment had been concluded.

Findings.—(1) "On the basis of efficiency as measured by *percental attainment*, by *lasting impression* on the minds of elementary school pupils, by *persistence in memory*, by *encouragement of independent thought and self reliance*, and by *popularity among the pupils*, the three methods rank . . . *experiment method, lecture method, book method.*"

2. "On the basis of minimal time consumption in the actual teaching of the lessons, of arousing and holding interest and attention, and of the minimal expenditure of mental and physical energy, they rank as follows—*lecture method, experimental method, book method.*"

3. "On the basis of minimal time consumption by the teacher in preparation of the lesson, they rank *book method, lecture method, experiment method.*"

4. "The amount retained in thought work, as well as in memory work in elementary science is inversely proportional to the length of time elapsing between the presentation and the test."

5. "Carefully written note-book work and neatly drawn diagrams of scientific apparatus do not increase pupils' knowledge of elementary science."

6. "The work in elementary science must be concrete and must be based on daily experiences and observations of pupils."

7. "Elementary science in the elementary schools should be largely, if not entirely, qualitative, and not quantitative."

8. "As regards elementary science, elementary school pupils cannot get the thought of the printed page. Simple diagrams are of no material aid."

9. "The *book method* of teaching elementary science might be used with fairly good results, provided the class is exceptionally bright."

10. "Pupils who are taught by the *book method* show superior ability in the power of expression and in spelling of new scientific terms, as well as of familiar old ones."

11. "The *combination method* consumes more time than the other three, but does not produce better results."

12. "Since the *experiment* and *lecture methods* approach each other in so many respects, either may be profitably used. Each produces good results. An ideal method might result from a combination of the two."

13. "On the whole the time of day, previous mental work, weather, and temperature conditions did not effect the work one way or another."

14. The value of repetition and extended period of study were shown.

15. "Poor experimental demonstration, no matter how plausible the excuse, is detrimental to efficient teaching . . ."

16. Relative popularity of the methods with the eighth-year boys was indicated by 88 votes for the *experiment method*, 23 for the *lecture method*, and 11 for the *book method*.

STUDY NO. 3L

Some Experiments in High School Instruction

By I. M. Allen*

UNIT I

Problem.—To determine whether the "*informal problem method*" of treatment of subject-matter in science in which attention is focused on a few central facts and principles, in which more time for application and assimilation is given by cutting down the amount of content to be recited upon, and in which pupils are encouraged to think upon short assignments of principles rather than to memorize text-book content, (1) is effective in securing assimilative learning as contrasted with memory of subject-matter, and (2) is more effective in securing assimilative learning than the ordinary *text-book method.*

Method.—The subjects of this investigation were a class of high school Freshmen in general science, of whom the average age of the girls was 15.6 and of the boys, 15.7; they had had no nature study or science in the grades. The course was elective and ran for ½ year. The instructor who was inexperienced but in sympathy with the plan of this investigation, wrote his own course in elementary science, selecting his *own* subject-matter and including only such material as he thought important. This course was printed in 65 lesson leaves, each consisting of definitive and explanatory material on some unit topic in physics, chemistry, or biology, followed by suggestive thought questions for reference work. These lesson leaves were given

* *The School Review*, January, 1914. Vol. XXII, pp. 26–44. This abstract is of only such portions of the original article as bear directly upon the experiment in the teaching of science.

one at a time to the pupils to be filed in loose-leaf notebooks together with notes, drawings, and descriptions of the experiments performed in connection with the lessons.

The recitations were conducted by "the informal and problem method of treatment"; questions were put by the teacher and answered by the pupils always in complete sentence form; accuracy and clearness were insisted upon. The experiments supplementing the lessons were usually performed by the teacher. Experiments were written up and were subject to explanation by the pupil at any time on demand. The class stayed on each lesson until the pupils had "warmed to it," and no attempt was made to cover any specified number of lesson leaves during the term; about 50 were covered. The pupil was made to stick to the problem until he had solved it and knew he had solved it.

As assimilative test (one constructed to reveal what knowledge had become the "pupils' own" rather than what content "he could remember of somebody's else knowledge") was given without warning after eight weeks, following a three-day developmental recitation on the barometer; the purpose of this recitation had been to lead the pupils to discover whether damp air is lighter or heavier, volume for volume than dry air. The same test was given on the same day to a class in physics composed of 21 Senior girls who had studied the barometer as treated in physics, and who had been instructed by a teacher more experienced than the teacher of elementary science. The test was to answer the following problem and give reason for the answer:

The barometer read yesterday, 29.63. Today it reads 29.47. You also remember that yesterday was a clear day and that today is cloudy. Does this show that the air is heavier or lighter than yesterday and why?

Findings.—(1) The percentage of right answers given by the Freshmen was 96 per cent and by the Senior girls 19 per cent; the percentage of right reasons given by the Freshmen was 89 per cent and of the Senior girls, 9.5 per cent.

2. "Assimilative tests are severer than the usual memory tests of the school [since they] are not based on recent matter, or matter recently reviewed, [and since they] always involve application of principles, and test power to think rather than power to recall."

3. "To develop power to think takes time. High school courses should be intensive rather than extensive."

UNIT II

Problem.—To determine whether pupils trained by the method described in Unit I acquire an attitude of mind and can reason in other sciences as well as or better than older pupils not so trained.

Method.—Six Freshmen selected at random from the experimental class were unexpectedly assigned for one day to a physiology class made up of Juniors and Seniors taught by the same teacher who taught the class in elementary science. The teacher took up an entirely new section of physiology, many lessons in advance, and conducted the recitation that day on the same informal plan (development through questions and answers) that he used with the class in elementary science. The assignment for the following day resumed the work at the point in the text-book where the experiment lesson had interrupted. To eliminate as far as possible the element of memory, no hint of the coming test was given either group. Four comprehensive questions upon the preceding day's recitation were given as a test the following day.

Findings.—(1) The six Freshmen scored 90 per cent, the six best members of the Junior-Senior class scored 87 per cent, while the remaining members of the Junior-Senior class scored 73.6 per cent.

Conclusions Tentatively Based by the Experimenter on Both Experiments.—(1) "All knowledge to be of possessory character must be *assimilated* or *made one's own*."

2. "This assimilative stage can best be reached through informal problem method of the classroom and as exemplified in the above experiment."

STUDY NO. 4L

The Psychology of Drawing with Special Reference to Laboratory Teaching

By Fred Carleton Ayer*

Problem.—To determine with respect to laboratory practice the relative merits of representative drawing, verbal description, and analytical drawing.

Method.—This experiment was conducted with a first year high school class in general science and several groups of graduate and undergraduate university and normal school students, to evaluate representative drawing, verbal description of the object drawn, and various types of analytical drawing.

* Doctor's thesis. Baltimore, Maryland: Warwick & York, Inc., 1916, pp. 107–168. Only such portions of the above study as pertain to the teaching of science are here briefly summarized. A brief digest of this study combined with "The Extent to Which Drawings Contribute to an Understanding of Scientific Facts," by Olive Flora Bryson (unpublished) is given, *Third Yearbook*, Department of Superintendence, N. E. A., 1925, p. 300.

A representative drawing is one "which reproduces as accurately as possible the exact appearance of an object." Analytical drawings are those in which "imitation is not the chief end, and in practice are a blend of two or more of the following types of diagrams":

(1) Those omitting certain details of surface appearance, as, for example, an outline drawing. "Whatever is shown is emphasized at the expense of the characteristics left out."

(2) Those in which the actual appearance of the object is altered, as in physiological cross-sections.

(3) Those showing "more than the eye can see, as, for example, a drawing showing a shoe with the outlines of the foot and the bones."

(4) "Symbolic drawing showing characteristic features only, which a number of objects have in common," as, for example, one showing the general appearance and characteristics of a dog, but not of any particular dog.

Retention values and other psychological values were determined in an elaborate series of five investigations. The drawing tests and descriptions were scored on the point basis by 10 competent markers.

Findings.—(1) The highest type of laboratory instruction is attainable only by adapting procedure to individual differences in ability to draw and to use graphic expression.

2. ". . . training in scientific expression is a legitimate and should be a regular part of the work in English."

3. "It is a waste of time, in the interests of scientific thinking, to require pupils to spend extended periods of time at representative drawing. In fact, it is worse than a waste of time, for it encourages bad habits of analytical study which are opposed to the interests of scientific thinking and constructive research." "The excessive use of representative drawing is a serious pedagogical formalism which produces copyists instead of scientists and which creates distaste instead of enthusiasm for science."

4. "Description is a desirable record of the work of the pupil," but "it is necessary . . . to supplement and direct

pupils' attempts at description." "Description aids retention by establishing numerous secondary associations during the period of observation and writing." "Subsequent recall is greatly facilitated by the number and strength of these associations."

5. "The results of the various special tests show that representative drawings do not afford a measure of the pupil's progress, or an adequate record of the work which he has accomplished."

6. Not only does representative drawing fail to aid the memory, but, as far as scientific concepts are concerned, even interferes with it.

7. "Analytical drawings are ideal records of work accomplished and should be used wherever adaptable to the laboratory exercise. They require but a minimum of time for execution, can be made without exceptional skill of hand, and may be readily inspected."

8. "Analytical drawing aids retention in the same manner as does description."

9. "The attempt to draw from memory tests the retention of space and form relationships." ". . . the attempt to draw from memory supplies the direction of attention to the visual characteristics of an object which is lacking in representative drawing."

10. "It is recommended that the device of representative drawing shall be supplanted in laboratory teaching by the use of description, memory drawing, and analytical drawing."

STUDY NO. 5L

The Place of Numerical Problems in High School Physics

By D. P. Randall,* J. C. Chapman, and C. W. Sutton

Problem.—To determine "the extent to which the present teaching [of physics, in which a more descriptive and qualitative method of treatment is substituted for the earlier quantitative method] accomplishes its purpose in securing a thorough grasp of the underlying principles of the subject . . . as far as mechanics is concerned."

Method.—The subjects of this investigation were 238 pupils, 165 boys and 73 girls, in four "typical high schools in a city system representative of distinctly progressive educational methods. Any conclusions drawn as a result of this study may therefore be taken as representative of the general condition." The average age of the pupil was 16½ years; all had studied mechanics within the year, devoting on the average 60 periods to class work and 48 periods to laboratory (a period representing 40 minutes' work).

The subject of mechanics was chosen because in it "quantitative or simple numerical problems must have greater emphasis than in any other branch of elementary physics."

A test was administered to these pupils consisting of 14 problems chosen to satisfy the following requirements: (1) they must "cover the ground of the usual high school course in mechanics"; (2) they must "range from simple to fairly complex problems"; and (3) they must "require only the very simplest arithmetical calculations, thus reducing the mechanical errors to the minimum." The

* *The School Review*, January, 1918. Vol. XXVI, pp. 39–43.

test was administered without previous warning in a single 40-minute period; no questions were permitted. The pupils might take up the problems in any order, working on separate loose sheets and recording, in the spaces provided, not only the answers but also the proper units.

Findings.—(1) ". . . taking the whole body of pupils, —on the average each problem is successfully solved by only 15 per cent of the pupils; no problem is solved by more than 69 per cent, while two straightforward problems were out of the range of every pupil. This reveals a condition truly surprising. The extent of the lack of comprehension shown therein of the numerical relations of the simplest and most fundamental principles of physics is certainly startling, and lends support to the criticism often heard that the average high school student of physics acquires merely a mass of disconnected facts, with little notion of the underlying and unifying principles. It is clear that the present method of teaching physics fails in its object in so far as it attempts to give the pupil any knowledge of principles which lie back of the common numerical problems. Haziness and guesswork in the realm of the exact are forerunners of lack of appreciation of, or even contempt for scientific method."

STUDY NO. 6L

An Experimental Study of Methods in Teaching High School Chemistry

William H. Wiley*

Problems.—(1) To determine the best[1] of three methods of teaching chemistry, the *text-book recitation method*, the so-called *lecture method*, and the *laboratory method*, and (2) to study the sex differences and the individual differences in learning chemistry by the above three methods.

Method.—The subjects of this investigation were 24 pupils, 16 to 20 years old, in the Junior and Senior years in the McGuffy High School of Miami University. They were probably slightly superior to the average high school pupils owing to their environment and training. All had studied physics but none had studied or were familiar with chemistry. They were divided into three groups of eight each, on the basis of individual averages determined by dividing by two the sum of their marks in physics, and on what they had been able to remember and write down of a special lesson which had been read to them once and which they had read once. The groups were considered to be equal when the sums of these individual averages for all the pupils in each group were equal.

By a series of preliminary investigations the investigator determined the necessity for controlling the entire lesson as

* *The Journal of Educational Psychology*, April, 1918. Vol. IX, pp. 181–198.

[1] By "best" is here meant the one which gives the best results in the least possible time and with the least expenditure of energy, as shown by permanent retention as well as immediate recall, and by the effects of the different methods on the pupil in regard to interest, attention, and fatigue.

well as the tests, because of the inability of the pupils to carry out the directions. Three lessons were written by the investigator: I. "What makes things burn?" II. "Why is baking-powder used in cake?" III. "How is cloth colored?" Each lesson contained the important ideas about each problem named; all were of practically the same length and were typewritten on uniform paper, a copy for each pupil. These lessons were standardized as to relative values and difficulty by giving all three a day apart to five pupils who had no previous knowledge of chemistry, and who were marked on what they could write of the contents after reading the lesson sheet once.

With the *text-book recitation method*, the pupils were told to study the lesson carefully until they felt they knew it. "Anything not understood was explained." When the majority stated that they knew the lesson, all copies were laid aside and the investigator asked questions covering the important points of the lesson, and answered any questions the pupils asked.

With the *lecture method* the materials and apparatus were arranged on the table; the investigator presented the problem to the class and informally discussed the material on the pertinent typewritten sheet. While lecturing, he performed the experiment to illustrate the subject-matter on the sheet, occasionally asking a question which he thought the class could answer; he wrote new and difficult words on the blackboard, and at the end summarized the important points in the lesson.

With the *laboratory method* each pupil was assigned a definite place in the laboratory and was then given the problem and the sheet to read containing directions for the lesson. While the class read the lesson-sheets, the investigator passed about, placing upon each pupil's desk what-

ever the pupil decided that he needed in performing the experiment. The pupils then performed the experiment under the watchful supervision of the investigator, who continually asked questions of different members of the class to be sure that the main points of the lesson were being established. When the pupils had concluded the experiment, the investigator had some of them summarize the points of the lesson and show how they had solved their problem. The pupils were permitted but not required to take notes. The time required for each method was noted.

In each experiment, immediately following the lesson the pupils were required to write out the lesson as they remembered it. A week and also a month later, without previous warning or preparation of any sort, the pupils were required again to write out the lesson.

These tests were marked by the investigator and the Head of the Department of Chemistry in Miami University. The lessons were divided into a definite number of important ideas and a second group of unimportant or amplifying ideas, the former with two credits and the latter with one; the lessons were then revised so that the value of all credits in each lesson should total 40. In marking, full value was given for the idea correctly stated, half for a partly correct answer, and none if the answer were missing. If an incorrect idea was stated for the correct idea, one credit was deducted from the total. Ideas not in the original lesson were not credited.

The general findings were based upon an elaborate consideration of the total scores of the individuals in the three groups for each method, each lesson, and each test. Individual differences were studied from results obtained by taking the sums of the scores which each individual scored

with each method in all the tests combined. Sex differences were determined by considering the average scores of all the boys and girls with each method and in each test.

Findings.—(1) "There is not so great a difference as is ordinarily supposed in the values of the three methods, *lecture*, *text-book*, and *laboratory*, so far as imparting knowledge is concerned.

2. "For immediate learning, the *text-book method* is unquestionably superior.

3. "For permanent learning the *laboratory method* is perhaps slightly superior.

4. "In every respect the *lecture method* is the least effective in imparting knowledge to high school pupils.

5. "From the point of view of expenditure of time, the *laboratory method* is the most costly and the *text-book method* the least. Ranking the three methods in order of economy of time they would stand: (1) *text-book*, (2) *lecture*, (3) *laboratory*.

6. "The rate of forgetting is greatest with the *text-book method* and least with the *laboratory method*. Whether the difference is enough to counterbalance the greater expenditure of time and thus make the *laboratory method* most efficient, is open to question.

7. "Girls learn more readily than boys by all the methods, and more especially by the *laboratory method*. The question might be raised as to whether this fact may be due to greater retentiveness on the part of the girls or a more careful attention to details in the learning process.

8. "The different methods show decided individual differences both for immediate and delayed reproduction.

9. "Probably a combination of the three methods will give best results in the teaching of high school chemistry."

STUDY NO. 7L

A Study of Note-book and Laboratory Work as an Effective Aid in Science Teaching

By Thomas D. Phillips*

Problem.—To ascertain the relative effectiveness of the various types of laboratory instruction, as shown by the pupils' recollection of experiments performed several months before.

Method.—A group of pupils in physics were examined in three types of experiment: (1) that which the pupil had himself performed and recorded in his note-book; (2) "that which had been performed by the instructor and recorded, calculations and conclusions being made by the pupil"; and (3) the ordinary demonstration experiment which had been performed by the instructor and discussed by the class but of which no note-book record was made. "Attempt was made to select experiments of equal interest appeal, and as the test was not contemplated at the time, they were performed under normal teaching conditions." For each type of experiment the answers were marked for three features: (1) description of the apparatus and materials; (2) method; and (3) nature of data and conclusions drawn. Each feature was marked as either complete and accurate, acceptable, or not satisfactory.

Findings.—(1) Writing of the note-book record is more effective than manipulation in impressing upon the pupils permanently the details of apparatus and procedure. "The failure of an unrecorded experiment to fix details of apparatus was very marked."

* *The School Review*, June, 1920. Vol. XXVIII, pp. 451–453.

2. "A large percentage of pupils are found accurate in statement of method when they themselves have carried out the work."

3. "The two demonstration experiments show the same number of unsatisfactory answers, indicating the value of note-book records here is in fixing details of procedure and not general knowledge of the method."

4. The results of the two demonstration experiments are "more clearly interpreted than when the pupil does the work himself. Here again the note-book record is instrumental in fixing the impression made by the demonstration."

5. ". . . the advantage of the note-book lies in securing accuracy of statement . . . [and] pupils get a 'general idea' as well without such a record."

Summary.—(1) "The laboratory experiment has no advantages over the demonstration method in teaching a law of physics."

2. "The laboratory experiment has value in familiarizing the pupils with the apparatus and methods of procedure."

3. "Note-book recording is valuable in securing definiteness of information."

Suggestions.—(1) "There should be a decrease in the number of general laboratory experiments performed by the pupil with a higher standard of accuracy set and more careful discussion made. This laboratory work should furnish training in careful manipulation, an appreciation of finesse of measurement, and a confidence in the apparatus which can be secured only by working with it.

2. "In place of laboratory experiments omitted, substitute demonstration experiments to be recorded in note-books. Especially there should be demonstration of laws and principles where the interpretation of data is not obvious and where a discussion is not required.

3. "Whether or not the record of the demonstration experiment is to be included in the pupil's note-book, if it be desired that he have some definite knowledge of details, insist on a formal write-up.

4. "Make use of the note-book as a valuable aid to teaching—and learning."

STUDY NO. 8L

Individual Laboratory Work versus Lecture Demonstration in High School Science

By Harry A. Cunningham*

Problem.—To determine whether the *individual* experience of a pupil in *laboratory work* pays for the extra time and trouble; or will as good results be achieved more economically from the *lecture demonstration method;* or will better results be achieved by *individual laboratory work* under some conditions and by the *lecture demonstration method* under other conditions?

Method.—Twenty-five Sophomores in high school botany were divided into two groups as nearly equal as possible in ability, on the basis of the results of the Chicago Group Intelligence Test and of their previous marks in their high school work.

Thirteen experiments were used in the investigation, each given to one section as a *lecture demonstration* and to the other as *individual laboratory work.* The exercises given might be roughly divided into three general classes: (1) those of which the purpose is to clarify the child's concepts

* Master's thesis. The following abstract of this study is made from a brief report under the title, "Individual Laboratory Work versus Lecture Demonstration," *University of Illinois Bulletin,* December 6, 1920. Vol. XVIII, pp. 105–107.

and give him new concepts through observation, but in which no problem arises and no reasoning to conclusions is necessary; (2) those exercises each of which gives rise to a problem the explanation of which depends upon knowledge which the pupil does not possess and which is furnished him; and (3) those exercises in each of which the pupil not only must observe but must reason to his correct conclusions unaided.

Each exercise demanding reasoning was written up under three heads: (1) "what was done"; (2) "what happened"; and (3) an "explanation of why it happened." On each pupil's written report of 10 of the exercises was marked the number of minutes required by the pupil from the time he began the exercise until his paper was ready to be handed to the instructor. Each pupil was scored on each of the three divisions of each experiment and on the experiment as a whole on the basis of a list of all the different points made by all the pupils under the three divisions of the same experiment; thus, if he made on the "what happened" division of a certain experiment 6 points when all the pupils together made on the same division of the same experiment 12 points, his score was 50 per cent of the total number of points under that division. "The results were obtained immediately after the experiments were performed."

Findings.—(1) The average savings of time secured by the *demonstration method* over the *individual method* was 12.2 minutes (almost 30 per cent). "In only one exercise did the *individual* workers make better time, and these results were due to different methods of making the observations."

2. "Under the 'what was done' division we have the following conclusions:

"Pupils can get what was done in a difficult method of procedure as well or better by doing *individual laboratory work*.

"The *individual* workers did not take very careful note of what was done in experiments whose methods of procedure were too common to draw their attention sufficiently to enable them to fix each step of the procedure in mind."

3. "Under the 'what happened' division we found:

"Experiments that must be started before the regular period or which must be continued after the class hour, give, as a rule, practically the same results by both methods.

"In an experiment that must run from day to day, such as the one on osmosis, the pupils will take more interest in making the observations if they have been active agents in setting up the experiment and will therefore give better reports in the 'what happened' division.

"If the exact results of an experiment are difficult to obtain, such as the color tests for food, the *individual* workers will make a lower score in this division, because many of the pupils will not get the exact results."

4. "The results obtained under the 'explanation' division may well be considered the most important of all and were as follows":

In experiments that involve familiar apparatus and easy methods of procedure as good results or even superior may be secured by the *individual laboratory work* as by the *lecture demonstration method*, because in such cases the pupil's mind is sufficiently free from the details of the procedure to enable him, as he proceeds with the steps of the experiment, to consider the results and their explanation more carefully.

"As the complexity of the apparatus and the difficulty of the method of procedure increases, less and less valuable results are secured in the explanation through the *individual*

work, owing to discouragement and distractions which the pupils encounter.

"Those getting the work as a *lecture demonstration* made 7 per cent higher average in the 'explanation' division, than those doing *individual laboratory work*."

5. In the *lecture demonstration experiments*, the pupils made a final average upon all the exercises, 5 per cent higher than the final average made by those who did *individual laboratory work*.

STUDY NO. 9L

The Educational Values of Certain After-school Materials and Activities in Science

By Morris Meister*

Problem.—To determine the relative values of play units based upon scientific toys and outfits, and of class room teaching of the same units with respect to (1) knowledge the pupils have carried away, (2) ability to understand and interpret phenomena enacted before them, (3) ability to perform practical tasks with actual materials, (4) constructive ability.

Method.—The experiment was preceded by three years (1916–1918 in the Speyer school and 1918–1919 in the Horace Mann school, both in New York City) "of enforced experimentation with science activities of all types, originating in the after-school interests of the boys. Though no organized effort was made to measure the actual value of this activity, it was carefully watched and studied."

* Doctor's thesis. Digests are to be found under the title, "The Educational Value of Scientific Toys," in *School Science and Mathematics*, December, 1922. Vol. XXII, pp. 801–813; and in *General Science Quarterly*, March, 1923. Vol. VII, pp. 167–180.

The subjects of the experiment proper, which covered two years, 1919–1921, were four groups of about 25 boys each, of about equal mental age and intelligence quotients, two groups formed from the fifth grade and two from the sixth grade. Group A had both teaching and play; group B had only teaching; C had only the play; and D (the control group) had neither. During the school year of 1919–1920, play with scientific toys and outfits was permitted to go uncontrolled and teaching also, in so far as the experiment was concerned; tests at the close of the year, given only on overlapping material, were used as the basis of measurement.

During the school year of 1920–21, the Science Club to which groups A and C belonged had play organized into 20 units based upon the most popular toys; 15 of the 50 boys in both groups played at a time in the Science Play Shop one 35- to 45-minute period per week for 20 weeks. No reward was given for the activity and attendance was voluntary. Each boy in coming in was asked to choose a unit with which he had not played before; having made his choice he was given a box of materials not essentially different from the scientific outfits (Chemcraft, Meccano, etc.). With this was a card which listed the materials needed; which suggested without telling how to accomplish them, certain minimum possibilities previously determined by noting and recording what 15 boys did with each of the 20 units; and which gave the stimulus to do some original stunts with the apparatus. The instructor while present to see that the boys did not interfere with each other, that they did not attempt anything dangerous, and that all necessary materials were at hand, made no "attempt to answer questions, give suggestions, or aid in any way."

Group A which had the play, and group B which did not, were given identical instruction in an entire year's course of study based on these 20 play units. The instruction time was 45 minutes per week, in two periods of respectively 30 and 15 minutes, for 20 weeks. "The material was first graded for difficulty, and then grouped so that oft-recurring principles could be presented early in the course," but "units were not merged." "Each lesson was a fully developed teaching unit, involving apparatus, demonstrations, class-discussions, pupil reports, home assignments, reviews, note-book work, and quizzes." Several play units were not covered by these classes because of lack of time.

In 1919–20, four types of tests based on 10 overlapping units were given to groups A, B, and C: (1) the conventional essay type for knowledge; (2) one in which the examiner performed one after another 20 experiments with apparatus involving "the essential knowledge or appreciations of the overlapping material for the year"; after each demonstration the class was given two minutes in which to write an explanation and their understanding of what they had seen; (3) one in which each pupil was asked to do with actual apparatus 10 tasks based upon the overlapping units; and (4) one in which constructive ability was measured with the Stenquist Box Test, used both at the beginning and the end of the year.

In 1920–21 a similar series of tests was given to all four groups on the common units of play and teaching, but a smaller number of questions per topic was given. Since the visual and practical tests were not standardized the experimenter gave the former test to various grades and teachers, and ranged the answers from worst to best; for the practical tests, he marked a given exercise as right or wrong.

Findings.—The following are selected from a list of 40 as bearing upon the learning aspects of this experiment:

1. "Extra-curricular activities in science make for almost as good a knowledge and appreciation of enviromental phenomena as do curricular activities."

2. "Extra-curricular activities in science make for better control of physical and chemical elements in our environment."

3. "Extra-curricular activities in science make for better constructive ability; that is, ability to fashion raw materials into usable things."

4. "Extra-curricular activities in science encourage and stimulate activities that give a boy first-hand experiences with natural phenomena. Their activities agree closely with youthful activities of great scientists and they contain elements in common with laboratory procedure of great scientists."

5. "Extra-curricular activities in science represent the type of purposeful activities which encourages originality and inventiveness, and habituates boys to experimental procedure."

6. "Boys who participate in both curricular and extra-curricular activities excel all others" in the abilities mentioned in all the preceding conclusions.

7. "The average I. Q. of boys who join the Science Club is always slightly smaller than the I. Q. of those who do not . . ."

8. There seems to be little correlation between the I. Q. and standing in the club, or between I. Q. and Stenquist ability, or between I. Q. and score in the "Practical Test."

9. "In general the very expensive toys are not more educational or more fun-producing."

10. "At 14 years of age there is a marked change in the type of interest a boy has in toys. Though after-school science activities do not diminish appreciably, there are no toys sold which meet his needs completely."

11. "The chief characteristic about a boy who succeeds in overcoming a difficulty is that he almost always finds a new problem arising out of the old one."

12. "The Science Club is an organization which may serve as a medium through which after-school activities in science may be stimulated, guided, controlled, and developed."

STUDY NO. 10L

An Experiment in the Use of Three Different Methods of Teaching in the Class Room

By George William Hunter*

UNIT I

Problem.—To test the values of (1) the *developmental method* ("the experimental method applied orally in the class room"); (2) *the lecture method;* and (3) *the text-book method,* with respect to immediate recall of memory work and retention; and to determine the relative values of the three methods with respect to the development of power as revealed by the pupils' ability to answer thought questions.

Method.—Three first year classes of respectively 30, 35, and 25 boys of median age 15 (range 12 to 18 years) were used as the subjects in a series of investigations carried on in 1916 in the DeWitt Clinton School, New York City. The experiment was explained to the pupils who were urged to

* *School Science and Mathematics,* December, 1921. Vol. XXI, pp. 875–890; January, 1922. Vol. XXII, pp. 20–24.

do their best to make their class score above that of some other class against which they were pitted. All three methods were tried out on the same day but each method was used in turn (rotated) with each experiment group on three successive days. As nearly the same type of lesson material and the same general type of questions as possible was used with all three groups each day. The material was taken from Ritchie's *Primer of Sanitation* and was found in the chapters on "The Relation of Mosquitoes to Yellow Fever and Malaria" and "Other Protozoon Diseases."

With the *text-book method*, an actual test was used in every case. The pupils quietly studied the assignments given; no questions were given or answered. After 20 or 30 minutes, the books were collected and a test was given, consisting usually of three questions, two testing memory and one, power. The relative values of the two parts of the examination were later reduced to a percentage basis.

With the *lecture method* the teacher attempted to follow accurately the material presented in the text-book, showing charts or making blackboard drawings to take the place of illustrations in the text; where an experiment was described, the teacher performed it, or if demonstration proved impracticable, the teacher explained it. No asking or answering of questions was permitted; the pupils were told that they were expected to take notes upon what they considered the most important facts in the lesson. A test followed as above.

With the *development method*, the lesson was introduced as a problem which, it was understood, was to be discussed jointly by both pupils and the teacher. Freedom of discussion was encouraged but discussion was confined to the particular problem which had been set. Wherever possible, the concrete experiences of the pupil were introduced; the

teacher formulated questions attempting to "develop" the topic so as to build upon previous experiences of the pupil. Telling was used occasionally to bridge the gaps but there was never formal lecturing. The teacher tried to keep a rapid-fire of questions directed at all members of the class. A test was administered at the end as above.

Data blanks were employed in the tests so that laboratory conditions might prevail and the teacher know whether any outside factors were to be considered. Two types of questions were used in the tests: (1) the memory type confined to the lesson just given; (2) the type requiring ability to interpret relations. Frequently this latter type of question was formulated as a concrete problem, and in difficult questions of this type, abstraction was attempted. Care was taken to eliminate guessing and to differentiate between memory and power.

Quiz questions were dictated orally. While the pupils wrote the answers the teacher noted signs of fatigue, inattention, lack of interest, or the contrary. All papers for the entire investigation were corrected under uniform conditions two months later. One power question was given as much weight as two memory questions; proportional credit was given for partly correct answers.

To test retention, an examination was given after one week's time in the first experimental series.

Elements from all three days' tests were selected for the recall test which was subsequently given on the same day to each class at the beginning of the period. Also the experimenter gave to all three classes the last 10-minute quiz of the series one week after the series ended.

Findings.—(1) The developmental method took most out of the teacher.

2. ". . . for immediate retention and for development of power the *developmental method* stands first, the *lecture method* second, and the *text-book method* third."

In another investigation with the same three classes, another teacher in the department arrived at the same conclusions as did the experimenter, using the same three methods.

3. The results of the retention tests do not bear out the conclusions of Pyle with respect to retention, "An immediate memory test probably gives a fair index of permanent retention." As shown by average percentages of material retained, the *lecture method* showed the least loss on recall, the *developmental method* next least, while the *text-book method* showed the greatest loss. But the *developmental method* was still best with respect both to memory total and power total.[1]

UNIT II

Purpose.—To determine whether the personal equation of the teacher affects the effectiveness of method.

Method.—Three other teachers in the same department made each an investigation of the relative values of the three methods using exactly the same technique as that used by the experimenter in Unit I. "Wherever practicable" the groups of boys used as subjects were of equal size, age, and mentality. One of these teachers used the same groups as were used in Unit I.

Findings.—(1) Two teachers who favored the development of thought processes got better results with the

[1] The investigator points out frankly several inadequacies of his experiment: For example, he considers that he made too few test experiments upon which to draw conclusions and that he was unable properly to equate groups.

developmental method, but a third teacher, who ordinarily used the *lecture method* in preference, got better results with the *lecture method*. The investigator concludes that a given method which to one teacher may be of very great value, may lose much of its value in the hands of another teacher, especially if that teacher believes that a different method is better. ". . . despite our best efforts to safeguard an experiment, the personal equation is bound to play an important part."

STUDY NO. 11L

An Attempt to Determine the Relative Values of Visual and Oral Instruction in Demonstration and Experimental Work in Elementary Biology

By George William Hunter*

Problem.—To determine the relative values of *visual* and *oral instruction* in demonstration and experimental work in elementary biology.

Method.—The investigation was made in the Dewitt Clinton High School, New York City, with two first-term classes of "poor average mentality," numbering respectively 31 and 28 pupils. The experimental lessons were given during a succession of days "when the laboratory work was devoted to food-tests, digestion of insoluble foods in growing seedlings, and the work of the root in digestion and absorption of insoluble mineral salts."

With the "*visual* class" the teacher avoided oral work; "names and scientific terms were written on the board and

* *School Science and Mathematics*, January, 1922. Vol. XXII, pp. 22–29.

only such directions as were absolutely necessary were given."

With the "*oral method* class" "the teacher developed the problem using the *oral method* of demonstration and in addition asked questions of nearly every member of the class in an attempt to make clear the steps of the experiment." With both methods "the class was . . . allowed to take notes and write up as much as possible of the experiment at the time of the demonstration."

The second experimental lesson of this series was given with the same two classes taught by the same test methods a few days after the first experimental lesson; a third and a fourth experimental lesson followed immediately with the methods for the respective classes reversed. A test examination was given during the first 10 minutes of the period on the day following each exercise.

Findings.—(1) When the question asked after a 12-hour period was a pure memory question, the difference in attainments was found to be less relatively than when the question involved discrimination and comparison. The one test of the series in which the results with the visual method were superior to those obtained with the oral development method, required "pure reproduction memory. In the second test of the series involving a relatively difficult comparison and analysis, the visual method fails badly."

2. It is "easily demonstrated from a study of the individual papers that the boy of low mental equipment is helped much more by the *developmental oral lesson* than by the visual lesson. The bright boy . . . has the equipment to enable him to solve problems without so much help as his less fortunate classmate needs."

3. "The number of perfect answers is much higher by the *developmental oral method* than by the visual method."

STUDY NO. 12L

The Oral Method Versus the Laboratory Manual in the Laboratory

By George William Hunter*

Problem.—To determine the relative values with respect to laboratory experimentation with two methods: (1) A method in which the work is developed through *oral questioning* and *discussion* combined *with demonstrations*, and (2) a method in which the problem is worked out *individuatly* by each pupil, guided solely by the directions in a manual.

Method.—The subjects of this investigation were the same two classes of boys used in Study No. 11L. Both classes had the same problems and teacher. With one class the lesson was introduced with a brief oral discussion, after which the pupils were left to work with the material on their desks and the manual (one they had never seen before) in their hands. After 10 or 15 minutes of wasted time, during which the boys seemed at a loss what to do, the experimenter suggested re-reading the questions, and at length most of the boys got to work. "The rest of the period the teacher did little active work and the class seemed to be working slowly."

With the other class, the following period, exactly the same subject matter as was covered by the first class with the laboratory outline, was covered by means of the *developmental method with oral discussion and demonstrations*. The class evidently were more interested and showed signs of understanding the work given. The next day both classes were given short identical quizzes.

* *School Science and Mathematics*, January, 1922. Vol. XXII, pp. 29–32.

The experiment was repeated with the methods for the respective groups reversed. The "*oral development*" group took the experiment the second period in the day, following gymnasium; the "*laboratory manual group*" took the experiment during the last period but they took setting-up drill before going to work. The fatigue of the teacher was noticeable in the latter class, though that of the class was not so great. Thirty minutes were allowed the discussion group for learning. The same test was administered to both groups on the following day.

In the second experiment the "laboratory manual group" took a long time to settle down to work in spite of full explanations at the beginning of the period. Several pupils asked foolish questions indicating a lack of comprehension of the printed instructions, and several attempted to get help from their neighbors.

Findings.—(1) In the second experiment a few of the brighter boys covered more work by the "*laboratory manual*" *method* than was covered in the other class by the "oral development" method, but the averages of work for the classes were nearly equal.

2. Both classes made a strong attack in the quizzes, but the "*oral development*" group had more to say than the "laboratory manual" group.

3. "Based on comparative marks, the *oral laboratory lesson* was far superior to the laboratory manual lesson."

4. "Judged by the fatigue of the teacher, the *laboratory manual lesson* is much easier in every way."

5. "The five brightest boys showed motivation with the *laboratory manual method*, but the majority of the class worked much more intelligently and with more interest under the *developmental method*."

GENERAL CONCLUSIONS BASED BY THE EXPERIMENTER UPON RESULTS OF STUDIES NO. 10L, 11L AND 12L

1. "Of the methods tried in the laboratory the *oral problem development* was best fitted to the needs of the first year pupils in high school."

2. "The *oral development* of the laboratory experiment produced better results than the visual method of experiment."

3. "The *oral question and answer method* in the laboratory was more productive of results than when a laboratory manual was used without oral discussion."

4. The personal equation of the teacher was "a factor of considerable importance . . . sufficient to change the results of a given series of experiments." ". . . all attempts to analyze the ability of a group to answer 'power' questions by means of uniform examinations marked by teachers in committee is of little value because of the personal equations of various markers of the committee."

5. The experimenter suggests that this work should in no sense be considered final nor any results be considered as more than suggestive; the final conclusions must be based on much more work of a similar nature under laboratory conditions.

STUDY NO. 13L

The Project Method in Teaching Chemistry

By Ellinor Garber*

Problem.—To ascertain the comparative merits of the project and the non-project methods with respect to (1)

**School Science and Mathematics*, January, 1922. Vol. XXII, pp. 71–73. This learning study was appended to the end of a discussion of the project method applied to the teaching of chemistry.

pupil preference for the type of course, and (2) subject matter accomplishment, both with respect to range of information and power to use it.

Method.—Three classes in their second term of chemistry, taught by the project method and four other classes which had been taught by the non-project method were given three tests made up of various divisions of the Powers "Tests of General Chemistry": (1) involving writing formulas, the naming of formulas, completion and balancing of equations, and writing equations for familiar laboratory reactions; (2) involving the range of information; and (3) involving the ability to solve a problem-question demanding "the use of facts which the pupils had learned in other connections." The pupils in the project classes were tested with questions covering work which had been reported upon by other members of the class but which individual pupils had not worked out for themselves. The average intelligence of the classes was used as the basis of comparison of ability. The average intelligence of the three project classes was lower than that of the non-project classes, but the two highest and the lowest in average intelligence of the seven classes tested were project classes.

Pupils in two classes were asked to indicate their preferences frankly with respect to the type of course they preferred without regard to what they thought the teacher's preference to be.

Findings.—(1) On the basis of class averages, "the test results with the seven classes indicate that the accomplishment of the *project classes*, measured by standardized tests" was slightly better than that of the non-project classes, although the average intelligence rating of the latter was almost seven points higher.

2. "Pupils in a *project* class do get and retain information on the material which is reported to them by other pupils."

3. Nearly ¾ of the number of pupils expressing a preference, voted in favor of the *project method.*

STUDY NO. 14L

Testing Laboratory Resourcefulness

By H. A. Webb*

Problem.—To test the laboratory resourcefulness of high school boys and girls and college men and women to determine whether (1) laboratory resourcefulness depends primarily upon gaining familiarity with the laboratory equipment; whether (2) the male or the female sex possesses the more resourcefulness; and whether (3) laboratory resourcefulness is developed in men and women with maturity and without training.

Method.—A test in laboratory resourcefulness was devised consisting of the following 13 problems:

TESTS IN RESOURCEFULNESS[1]

1. (Set-up) A large bucket of water, fastened down; bottle; rubber tubing. (Directions) "Fill the bottle with water from the bucket, without moving the bottle."

2. (Set-up) Burner with short connection; plenty of glass and rubber tubing at hand; paraffin pan and stand two feet away, fastened in position. (Directions) "Light the burner and melt the paraffin."

3. (Set-up) Bottle; pan; tubing; gas-cock and water faucet near by. (Directions) "Fill the bottle with illuminating gas unmixed with air."

* *School Science and Mathematics*, March, 1922. Vol. XXII, pp. 259–267. Only the learning phase of this research is here abstracted from a longer article presenting other phases and conclusions.

[1] Items are ranked in order of difficulty, as shown by results.

4. (Set-up) Two bottles clamped one above the other on a stand; glass and rubber tubing and stoppers at hand. (Directions) "Fill the upper bottle with water from the lower."

5. (Set-up) Two bottles of odd shape; scales, sand, and water at hand; no weights. (Directions) "Which of these bottles holds the most?"

6. (Set-up) Two sealed bottles, of equal size and weight, one filled with water, the other with oil; scales; sand; no weights. (Directions) "Which liquid is oil, and which is water? Prove it."

7. (Set-up) Scales; sand; and 10-gram weight. (Directions) "Weigh 5 grams of sand, using the 10-gram weight."

8. (Set-up) Two rocks, one flat, one thick; large graduated cylinders near by, and water available. (Directions) "Which of these rocks is the larger? Prove it."

9. (Set-up) Two unequal bottles, one filled with water; sand; scales; no weights. (Directions) "Pour exactly half the water into the empty bottle."

10. (Set-up) A flask, filled with water, neck pulled out to a tiny opening. Water will not shake out. (Directions) "Empty water out of the flask."

11. (Set-up) Flask similar to above, but empty. (Directions) "Fill this flask with water."

12. (Set-up) Three unequal bottles, one filled with water; sand; scales; no weights. (Directions) "Divide the water into thirds."

13. (Set-up) Porcelain dish; tripod; burner; ring stand; clamps; large flask filled with water. (Directions) "Arrange this equipment so that the water may be evaporated in the porcelain dish while you are absent for an hour."

This test was first offered to students having absolutely no experience in a laboratory, then to one group of 43 high school pupils and another of 34 college students; both of these classes had had just enough experience in laboratory to eliminate the temporary influence of strange apparatus. The students worked individually and could not see what others were doing. Though the actual manipulations of any test item could be performed in less than one minute after the student had decided just what to do, the maximum

of five minutes for pondering and trial was allowed before failure was recorded. The time was taken for each individual on each experiment and the medians were recorded for each of the four groups on each experiment.

Findings.—(1) Students with absolutely no laboratory experience showed no laboratory resourcefulness whatever; they refused to touch the apparatus.

2. The males excelled the females both in the median number of test-items solved within the given time limits and in the median time required for solving individual test-items.

3. There was only a slight difference between the performances of the high-school and the college groups, "somewhat in favor of the high school, where one-minute responses are considered; slightly to the advantage of the college when the sexes in each group—men and boys, women and girls—are compared. Maturity does not develop resourcefulness spontaneously; men and women do not acquire ingenuity by mere circumstance of growing older. Neither may it be deduced that the bold assurance of adolescence is resourcefulness . . ."

STUDY NO. 15L

Technique in Chemistry Teaching

By H. A. Cunningham*

Problem.—To determine the relative results of teaching chemistry by two different methods: (1) the "*proverbial*" *plan;* and (2) an elaborate plan of *directed study.*

* School Science and Mathematics, April, 1922. Vol. XXII, pp. 356–362.

Method.—The subjects of this investigation were a class of 14 Seniors of very ordinary mentality and intellectuality, studying chemistry in the Community High School, Paxton, Illinois. During the first semester the work was carried on in the old "proverbial way": three days of recitation upon a certain number of pages from the text, and two double periods for laboratory work each week; but "an effort was made at all times to correlate the laboratory work with the text." The experimenter "did everything within his power, that was consistent with the 'three recitation and two laboratory periods plan' and with the very conservative traditions of the school" to insure a mastery of the subject matter by the class.

During the second semester, "a radical departure from the customary practice" was taken: All required work was accomplished in a double period, 80 minutes per day. The preparation of lessons in one descriptive text was no longer demanded but the different texts and other books related to chemistry were transferred from the school library to the chemistry room.

"A topical analysis was made of the material yet to be covered in the course and each topic was taught as a whole. Under each topic the minimum essentials which all must master were determined." In general, the teacher introduced each new topic by a short lecture, the purpose of which was: (1) to connect the new topic with the pupil's previous knowledge of the subject, (2) to give necessary information so that the pupils would attack the topic properly and without the loss of valuable time; (3) to arouse interest by giving information concerning the practical applications of the principles involved and by making reference to things of historical interest in connection with

the topic; (4) to agree upon an outline of the minimum essentials which every one must master.

"Next came an exhaustive study of the topic in laboratory work and in supervised study." No formal recitation work was attempted during this time,—generally a period of several days. As a general thing, this assimilation period was started by beginning with the laboratory work, though some pupils preferred to read a little on the topic before starting the experiments. As the work proceeded, definite references were given in the various text-books to pages and sections bearing upon every phase of the topic under discussion. During the laboratory work and after its completion, extensive reference work was done by each pupil, using the references as a guide. Such references often showed the pupils the necessity for doing part or all of their laboratory work over. References were given to any theory a knowledge of which was necessary to a thorough understanding of the topic.

All experiments were written up under three heads: (1) a statement of what was done; (2) a description of what happened; and (3) an explanation of why it happened. "Part one was a reference to directions given in the laboratory guide, and included any alterations or additional directions given by the instructor. Part two was made up of brief sentences stating just what was seen in the experiment. Part three was a full discussion of the reactions that took place, and included the equations for all reactions. The instructor went over each laboratory report, usually as soon as it was completed and often with the pupil himself; errors were indicated and immediately corrected.

A list of important questions and problems, made out for each topic, were worked through in supervised study. When the topic had been mastered, or nearly so, the pupils

filled in the outline formerly agreed upon, as a brief or syllabus. After the briefs had been completed, an examination was given covering every phase of the topic. The papers from this examination were immediately graded and the hazy points disclosed by the test were discussed again in class. The pupils then reviewed the briefs with the idea of getting ready for a "real recitation."

In the next phase of the work each pupil made an oral recitation upon some topic, or subtopic, requiring an extended discussion, following which the other members of the class had the liberty to ask questions of him or to make corrections or additional contributions to the topic under discussion. Sometimes the pupils recited from the skeletonized outline written on the board. Fundamental problems were solved on the board and explained in detail by members of the class, as their contribution to the recitation period, but the number of mathematical problems was reduced to the minimum. Work upon special topics was given to those who completed the assigned topic ahead of others.

"The distinguishing features of our change in technique are: (1) the abolition of required home, or outside study; (2) the adoption of a longer period for class work; (3) the abolition of the assigned lesson from a text-book, to be prepared at home or in the study hall and hashed over in recitation; (4) the basing of the entire course upon an extensive laboratory and reference study of certain units of subject matter; (5) a topical analysis of the course, at the beginning, into teachable units and the mastery of each unit as a whole."

Findings.—(1) With the first method from the start "very unsatisfactory results were obtained from all but the very best students." "During this first semester, there was

failure to get the important principles unified and their meaning and importance crystallized, in the pupils' minds." For all but the best three of four pupils, time spent in preparation of the text-book lesson outside of the recitation period was practically wasted.

2. The results at the middle of the second semester, as revealed by examination and class grades, tended to show that a much greater understanding and power were being gained than during the first semester. "The total class average for the first semester was 81.7 per cent, and for the second semester 89.1 per cent."

3. The new method eliminated discouragement on the part of the weaker pupils by convincing them "that they really could learn chemistry." This change of attitude "brought a new interest to the subject," a fact indicated by requests to be permitted to work in the laboratory at vacant study periods and after school, and by much extra-class work done on special topics and experiments.

STUDY NO. 16L

The Value of Valence and When to Teach It

By E. E. Rademacher*

Problem.—To determine whether the teaching of valence should precede or follow the teaching of formulas and equations.

Method.—Fourteen pupils, averaging about the same marks in the various sciences, were divided into two groups,

* *School Science and Mathematics*, April, 1922. Vol. XXII, pp. 363–364. This learning study is included incidentally in the report of the study of 83 replies to a questionary sent to 175 teachers of chemistry in Illinois, to secure their reactions regarding whether it is better to teach valence before or after teaching equations and formulas.

A and B, of seven pupils each. With group A the teaching of valence preceded, and with group B it followed the teaching of formulas and equations. The experimenter took "pains and interest" to make the three subjects, valence, formulas, and equations, clear to both groups. After five periods of instruction for each group, the two were united and given as a test the writing of 20 formulas and 20 equations.

Findings.—The average marks of both groups in both parts of the test were 88.5 per cent for group A and 69.6 per cent for group B, or an average mark 18.9 per cent higher for group A than for group B. The results of this investigation would therefore seem to indicate that valence should be taught before formulas and equations.

STUDY NO. 17L

Oral versus Written Instruction and Demonstration versus Individual Work in High School Science

By J. L. Cooprider*

Problem.—To determine the relative values of *oral* and *written instruction* and the relative values of *demonstration* and *individual work* in high school science.

Method.—Twenty-four laboratory exercises were given to 42 high school Sophomores in biology, who were distributed equally among three sections, equal in average mental ability as determined by the results from the "Chicago Group Intelligence Test." The average school grades of

* Master's thesis. The following abstract of this study is made from a report under the same title in *School Science and Mathematics*, December, 1922. Vol. XXII, pp. 838–844.

the pupils in the three sections, moreover, varied from each other by less than .6 per cent.

Four methods were used: (1) *demonstration with oral instructions* (instructions for working the exercise were given orally by the instructor who performed the demonstration immediately); (2) *demonstration with written instructions* (typewritten instructions were given the pupils to read before the performance of the demonstration by the instructor); (3) *individual work with oral instructions* (instructions were given orally by the instructor immediately preceding the performance of the experiment by the pupils); (4) *individual work with written instructions* (each pupil read the typewritten instructions and then proceeded to work the exercise). The instructions were the same in all four methods; only the method of presentation varied.

The record consisted of (1) "object"—statement of the purpose; (2) "procedure"—the complete record of steps performed in working the experiment; (3) "results"—the record of observations made by the pupil; and (4) "conclusions"—a summary of facts proved, tested, or learned.

The pupil's record was scored by the point and the percentage systems. The pupil's score in points was reduced to a percentage score on the basis of the number of possible points for each division of an exercise as determined by the instructor. The total score for each pupil on a given exercise was found by dividing by four the sum of the per cents earned in the four divisions of the exercise. This practice made the "memory factor" of the "object," the "manipulation factor" of the "procedure," the "observation factor" of the "results," and the "reasoning factor" of the "conclusions," all of equal weight.

To avoid irregularity in marking, one point was scored at a time in all sections. Errors were indicated on the papers

which were returned to the pupils. The latter were informed that their work was being carefully marked and thus their attention was assured, though this practice prevented testing results after a considerable interval of time had elapsed following the performance of the exercise.

Typical exercises in biology were selected, some of which attempted to clear up some problem with which the pupil was already somewhat familiar and which required no reasoning to the conclusion; others "demanded careful observation and discrimination in order to reach the conclusion"; others gave the pupil a problem demanding a reasoning to the conclusion; and still others presented a problem involving both a recalling of former exercises and a reasoning to the conclusion. In some exercises two or three types were combined to insure that the pupil's interest and attention were sufficiently aroused, that he kept the procedure in mind, was accurate in observation, and exercised a keen judgment. Only exercises capable of performance by all four methods were selected for the experiment.

In 12 of the 24 exercises the instructions for performing the exercises were oral, and in 12 they were written; 6 of each type (with oral or with written instructions) were demonstrated, and 6 were done individually.

Since there were only three experiment groups, no comparison was possible with one set of results obtained by one of the four methods. "In making comparisons between any two methods therefore the results of one of the three sections were eliminated in order that there might not be the factor of variation between the exercises themselves."

Findings.—(1) For immediate results as indicated by the data, the "exercises with *oral instructions* give better results than exercises with written instructions in both *demonstration* and *individual work*."

2. "*Individual work with oral instruction* is more efficient than demonstration work with oral instructions."

3. "*Demonstration work with written instruction* is more efficient than individual work with written instructions."

4. *Demonstration work* gave somewhat better results than the individual work, though the difference was slight.

5. The *individual method* took about *twice as long* as the demonstration method. "If the results of the demonstration work and the individual work are nearly the same, then, it seems that the *demonstration* work would not only be a time-saving device, but also a great saving in the purchase of extra laboratory equipment necessary for individual work."

6. That our present methods of science instruction fall short in teaching the pupil to reason scientifically, was shown by the fact that the "conclusion" results were so much below the "object," the "manipulation," and the "observation" results.

STUDY NO. 18L

A Preliminary Experimental Study of Technique in the Mastery of Subject-Matter in Elementary Physical Science

By Wilbur L. Beauchamp*

Problem.—To determine the relative efficiencies of two different methods of study, semi-directed study and directed study.

General Method.—Two classes of 26 pupils each, mostly in the eighth grade of the University of Chicago High School

* *Studies in Secondary Education, I,* Supplementary Educational Monographs, No. 24, Chicago, Illinois: The University of Chicago, January, 1923. pp. 47–87.

were equated upon the bases of age, native intelligence, rate of silent reading, and ability to interpret what is read. In the absence of data on the intelligence quotients of the pupils, this factor was secured by random sampling. To determine the reading rate and comprehension coefficient of each class, two reading tests were given, one a measurement of general reading ability, and the other a test of ability to read the subject-matter of elementary science.

The text, in mimeographed form, was handed out at the beginning of each period and collected at the close. "All absences were made up on the basis of time lost." In order to minimize the passing of information concerning the test from one class to another, the "directed study" class, which was given all tests first, met with the instructor during the last period in the day, while the "semi-directed study" class met with him during the first period in the morning. As a further safeguard against the passing of information regarding the tests from the "directed study" to the "semi-directed study" class, a spirit of rivalry was stimulated between the classes. Whatever oral presentation was from time to time necessary, was given by the instructor to both classes alike. The answers to the test questions were blocked out in advance to insure objective grading of the papers.

At the start the semi-directed study class excelled the directed study class both in rate of reading and in ability to interpret what was read, not only with respect to general reading ability but also in ability to read the subject-matter of elementary physical science; the semi-directed study class contained more pupils of higher intelligence, and the average pupil in this class was six months older than the average pupil of the directed study class; the intelligence quotient of the median pupil of the directed study class

was slightly higher than that of the semi-directed study class.

The following factors were kept constant throughout the experiment, which was started in October, 1921, and was completed, April, 1922: instructor, time spent in study, amount of material, tests, scoring, and oral presentation by the teacher.

The subject-matter of the course in elementary physical science was divided into teaching units, each organized around a naturally related group of phenomena, applications of these phenomena, or materials common in the life of each pupil. Each unit was divided into problems each working out some major division of the unit.

The instruction in each unit was divided into five phases: (1) the *preparation* or *explanation*, in which it was the teacher's task to ascertain in from 30 to 50 minutes what the pupil already knew about the unit to be studied, and by questions to connect the unit with the past experiences of the pupil and to raise new questions in his mind; (2) the *presentation*, in which the teacher presented orally in from 20 to 40 minutes an *overview* of the entire unit, containing little or no detail but presenting to the pupil a bird's-eye view of the general field to be covered in the unit; the presentation served to arouse interest, to present a definite goal for study, and to raise questions for future solution; (3) the *assimilation* which consumed from 10 to 20 days during which the pupil turned to books and the laboratory to obtain an understanding of the unit; (4) the *written report* or *organization*, in which the pupil prepared without the use of notes, a syllabus of the entire unit, which might be a topical or a sentence outline, or a full account in narrative form; (5) the *oral report*, for which the pupil prepared a series of talks on the major phases of the unit and on the

unit itself, at the end of which he was subjected to a cross-examination by both teacher and pupils.

The experiment was conducted over a series of units, each of which will be described with respect to its methods and findings separately:

UNIT I

Problem.—To determine how the semi-directed study class and the directed study class compare in their mastery of the subject matter of elementary physical science when the same study method is used in both classes.

Method.—Both of the classes received the following instructions at the beginning of the assimilation period:

How the book is written:

1. The unit title expresses the underlying thought of the entire unit. It supplies the goal for study. The written material in the text and the experiments are the means for giving you a complete understanding of how substances burn and produce heat.

2. The text is divided into a series of problems. Each problem makes a definite contribution to the understanding of the unit.

3. As a rule, the text of the problem contains questions. The purpose of these questions is to break up the problem by raising certain issues which are involved in the solution of the problem. The question contributes to the solution of the problem in the same manner as the problem contributes to the unit.

4. Experiments are found in many problems. The purpose of the experiments is to make clear some fact or principle necessary for the solution of the problem. The conclusion is the important part of the experiment.

5. Many words are underlined to call your attention to them.

6. The underlined sentences are very important. They may be summary sentences, or they may state some important principle or fact.

How to study the unit:

1. Read the problem title carefully. It raises a definite problem, the solution of which is in the text that follows. Keep the problem in mind as you study.

2. Before studying the problem in detail, read quickly through the whole problem to get a general idea of the whole.

3. On the second reading, read carefully, taking notes on the important points. If there is any part which is not clear, raise your hand and ask for help.

4. Before you begin a new problem be sure that you can answer all questions asked in the problem and can give a clear discussion of the solution of the problem.

During the four weeks of five class hours each spent on the study of this unit, there were no recitations, though occasionally there was an oral presentation of some point which the instructor found was not clear. Some of the experiments were performed by the pupils and some by the teacher. "In all deviations from the ordinary study the same procedure was followed in both classes." The abler pupils who finished before the rest, were assigned additional topics which did not contribute directly to the minimum essentials.

Three types of test were used: the written report, to measure the pupil's grasp of the entire unit; a completion test, "to measure the pupil's mastery of the technical terms used in the unit and the ability to apply what he learned to a new situation"; and a series of thought questions based on the application of the principles presented, "to measure the ability of the pupil to apply the principles learned to the solution of problems presented in his everyday experience."

Findings.—(1) "The median pupil of each class assimilated the subject-matter of the unit with the same thoroughness.

2. "The average number of points obtained per pupil is slighly higher in the directed-study class than in the semi-directed-study class.

3. "The directed-study class contained more pupils who thoroughly assimilated the subject-matter than the semi-directed-study class.

4. "The two classes contained the same number of pupils who did their work on a relatively low level.

5. "The upper $\frac{2}{3}$ of the entire group contained an equal number of pupils from both classes.

6. "The type of study used in this unit seemed to equalize the differences in the rate of reading and in the interpretation of what was read."

UNIT II

Problem.—To determine the value of studying a paragraph to discover its central idea and its outstanding contributing ideas, as compared with the undirected studying of the same subject-matter for the same length of time.

Method.—The semi-directed-study class followed the instructions given in Unit I. The directed-study class was given the following directions for studying:

1. Read the problem title carefully and then read quickly through the whole problem. Does the text answer the problem?

2. Read the first paragraph carefully. What is it about? Make up a paragraph heading which will express the central idea and write it in your notebook. Pick out the main ideas in the paragraph and list them in your notebook under the paragraph heading. Repeat with each paragraph of the other problems.

3. Try to answer the problem. The paragraph headings when combined will furnish an outline to the main point needed for its solution.

Both groups took notes in this unit, which was studied five 50-minute periods per week for four weeks; a series of three tests similar to those given for Unit I were given at the end of the assimilation period.

Findings.—(1) "The results obtained indicate that the method of instruction used in the directed-study class was more efficient [in assuring a thorough assimilation of subject-matter] than the method used in the semi-directed-study class by three standards: score of median pupil, average number of points per pupil, and tertile rank."

UNIT III

Problem.—To determine the value of formulating the questions one must be able to answer in order thoroughly to understand a topic as compared with undirected study of the same subject-matter for the same length of time.

Method.—The procedure was the same as that in Unit I except that the semi-directed-study class followed the study directions given in Unit I while the directed-study class was given these directions:

1. Read the problem title carefully and then read quickly through the whole problem.
2. Re-read the problem title. Ask yourself this question: What questions must I be able to answer in order to solve the problem?
3. Write the problem in your notebook.
4. Read each paragraph carefully. Each paragraph contributes a few facts or ideas needed to solve the problem. State the ideas in question form. Put these questions in your notebook.
5. As you study the problem, questions will sometimes be raised in your mind. These questions may be on some part of the text which you do not understand, some facts which are mentioned and which you would like to know more about, or other questions which come to your mind. Keep a record of these questions in your notebook.

Notes were taken by both groups as before. Three weeks of five class periods each were spent in the study of this unit.

Findings.—(1) "The results obtained indicate that the method of instruction used in the directed-study class was more efficient than the method used in the semi-directed-study class in the total number of ideas gained from study." It was not more efficient in obtaining an understanding of the technical terms or of the major relationships, or in the application of the principles learned in solving thought questions. "The results obtained in this unit are not conclusive. They indicate that there is one danger in this method of study, namely, that it focuses the attention on detail rather than on major relationships. This danger might be eliminated if the method was carried on for a longer period of time."

UNIT IV

Problem.—To determine the value of reading a unit entirely through to ascertain the general plan of the unit and then grouping the major facts presented around this plan, as compared with undirected study of the same subject-matter for the same length of time.

Method.—The semi-directed-study class followed the directions given in Unit I. The directed-study class was given special directions for study:

1. Read quickly through the entire unit.

2. Read the unit title. Ask yourself this question: What is the plan which the author had in mind when writing this unit? To discover this plan, scan rapidly through the unit and find the major ideas under which the subject-matter is presented. List the major topics in your notebook under the heading, General Plan of the Unit.

3. Now take Item 1 in your general plan and read through that part of the text which relates to it. Watch especially for sign-post

paragraphs, summary paragraphs, and topic sentences. Pick out the major ideas which are included under this item. For example, Item 1 might be "The Wind Belts of the Earth." This might be subdivided into the doldrums belt of calms, trade winds, and westerly winds. List these subtopics under the general heading and leave seven or eight lines after each one.

4. Study each subtopic carefully to determine the principal facts needed for a complete understanding of the topic. For example, the principal ideas needed in the understanding of the doldrums are their location, cause, direction of air currents, weather, etc. Include these ideas under the subtopic, "Doldrums." Use the sentence type of outline . . .

5. When you have finished studying each item in the general plan, write a summary paragraph which will show how that item contributed to an understanding of weather.

Findings.—(1) "The results obtained indicate that the method of study used by the directed-study class was more efficient in obtaining a thorough assimilation of the subject-matter than the method used by the semi-directed-study class."

UNIT V

Problem.—To determine the value of giving the pupils a method for solving thought questions and practice in solving thought questions, as compared with no specific training of this sort.

Method.—The first day a problem was presented to the class a method for solving it was given, along with a complete solution of the problem by this method, and the following summary of method of solving thought questions:

1. Analyze the problem by finding the part which furnishes the data for its solution.

2. Break up the problem into questions.

3. Recall any experiences or information you have concerning the problem.

4. On the basis of these ideas, formulate probable solutions of the problem.

5. Test your solutions to determine which is the right one.

6. Answer the problem.

Two problems in the form of questions were given to the class each day for solution; the questions were assigned at the end of the period, and the solution was brought in the next day. Each pupil was required to follow as nearly as possible the steps given and to write out just what he did in solving the problem. At the beginning of the period, 10 minutes were spent in solving the questions according to the foregoing plan. The directed-study class used the same method of study as in Unit IV and the semi-directed-study class the method outlined in Unit I. At the end of three weeks spent in this kind of training and practice, 16 thought questions, none of which involved the use of principles on which training had been given, were given to both classes.

Findings.—(1) "The results obtained indicate that special training in solving thought questions is desirable."

UNIT VI

Problem.—To determine whether the training in study had any effect upon the rate of reading and the ability to interpret what was read.

Method.—Reading tests, similar to the initial ones, were given to both groups in December and April.

Findings.—(1) "Training in making various types of analysis of the subject matter increases the ability of the student to interpret what he reads."

2. "Although it was impossible to measure accurately the increase in the rate of reading because the tests were not standardized the results indicate that the type of instruction

used resulted in an increase in the rate of reading in both classes, but that the increase was greater in the class which was not required to analyze the subject matter studied."

General Conclusions.—(1) "Specific training in finding the central thought of a paragraph, determining the questions one must be able to answer in order to obtain an adequate understanding of a topic, and reading an entire block of material through for its general plan, results in a more thorough comprehension of the subject-matter than undirected study on the same material."

2. "Specific training and practice in answering thought questions based on the application of some scientific principle are more efficient than incidental training in answering thought questions."

3. "Training the pupil to make various types of analyses of the subject-matter increases the ability of the pupil to interpret and reproduce what he reads."

4. "The gain in rate of silent reading is greater if the pupil is not required to make an analysis of what he reads."

STUDY NO. 19L

The Individual Laboratory versus the Demonstration Method of Teaching Physics

By E. W. Kiebler,* and Clifford Woody

Problem.—To evaluate the merits of the *individual laboratory method* and the *demonstration method* of teaching physics.

Method.—This investigation was conducted with two groups regularly taking physics. The groups were equated

* *Journal of Educational Research*, January, 1923. Vol. VII, pp. 50–58.

on the basis of scores in the Army Alpha Test. Each group contained good, average, and poor students, but only those whose attendance was perfect and whose attitude was conducive to good work were included in the investigation.

Fourteen experiments on heat were divided into two series of seven each; with the first series the individual laboratory method was used with group X and the demonstration method with group Y; with the second series, the methods with the respective groups were reversed.

In the *individual laboratory method* each pupil or group of pupils performed the experiment; in the *demonstration method* the instructor, assisted by one or two pupils, demonstrated the experiment, the import of which the pupils got through observation and discussion. The same preliminary assignments in the same text-book were made in each, and the same type of quizzes given to test the effectiveness of reading and understanding of new terms.

From this point on, the methods differed: With the *individual method* each pupil began to study the experiment as given in the manual, he prepared his "temporary sheet," gave a statement of the object of the experiment, listed the apparatus, and made a table suitable for recording data. A quiz was then given on "methods of performance"; special emphasis was placed upon necessary precautions and possible sources of error. The pupils then performed the experiment individually or in pairs, recorded data, made calculations, and wrote up the "temporary discussions." Later, after these had been corrected and general errors had been discussed in class, the pupil wrote up the experiment in permanent form.

With the *demonstration method*, after a short quiz on the assigned readings and new terms, the instructor announced the experiment for the day, asked the pupils to write the

purpose on a "temporary sheet," questioned the pupils on necessary apparatus which they listed. He then developed the necessary method, the necessary precautions and possible errors through questions, then, with the help of one or two pupils, performed the experiment before the class. The pupils copied the data written on the board, made calculations from them, and completed the "temporary discussion." Later, as with the laboratory group, after the sheets had been corrected and the errors had been discussed, each pupil wrote up a permanent record.

The results were measured by three types of test: (1) temporary or immediate knowledge of the facts of the experiment; (2) tests of performance or delayed knowledge; (3) tests of knowledge of how to apply principles and technique learned in attacking a new problem.

In the first, informal tests were given one to two weeks following each experiment; in the second, a general test was given two weeks after the seventh and the fourteenth experiments.

"In two experiments, as a variation of the method of testing for immediate and delayed knowledge, the test for immediate knowledge of the facts of the experiment was given upon completion of the 'temporary discussion,' and again two weeks after the experiment had been permanently written up."

In the third, the pupil was confronted with new problems; he was furnished with a list of needed apparatus and was given an informal test in which he was asked to make simple drawings showing how the apparatus would be used, and to fill out broken sentences describing methods of possible procedure. Each pupil in the individual method then performed the experiment and in the other group, the

instructor performed the experiment. Two weeks later both groups were rigorously tested again.

While all the tests used were informal, they were as nearly objective as possible and embodied many principles utilized in making standardized tests, completion, matching, true-false, and best answer.

Findings were based upon averages of the pupils' marks in each experiment and in each group of experiments.

Findings.—(1) With respect to immediate knowledge, in the first seven experiments the *demonstration method* showed superior results in five and inferior results in two experiments; in the second seven experiments, it showed superior results in three, inferior in three, and a tie in one.

2. Those using the *demonstration method* during the first seven experiments were more successful with the *laboratory method* in the second seven; this fact showed that at worst the *demonstration method* was no handicap to these pupils.

3. The *individual laboratory method* proved superior in those experiments difficult to demonstrate, but the *demonstration method* proved superior in those difficult for pupils to perform.

4. The advantages in permanent knowledge were in favor of the *individual method* but were "so slight that it is of little consequence."

5. A comparison of mean *scores* in both methods on the tests given immediately after the temporary sheet had been completed and again two weeks after the experiment had been written up, showed higher scores for the *demonstration method* in three out of four possible comparisons, possibly because the facts had been more vividly portrayed in demonstration.

6. The initial superiority of the *demonstration method* was shown by the fact that the group using the individual

method made much more gain in the second test than the group using the demonstration method.

7. The value of permanently writing up was clearly shown by the gains by both groups on the second test.

8. The *demonstration* group, when confronted with a new problem with only the apparatus given, were superior on the method of procedure before the experiment was performed and in the test after the experiment. Therefore the *demonstration* group "has as much ability in attacking new problems as the group trained with the individual laboratory method."

Summary.—"On the basis of the foregoing data, the following observations seem justified: (1) The results secured through the use of the *demonstration method* were as good, if not better, in all three types of tests given—the tests for immediate knowledge, for permanent knowledge, and for knowledge of how to apply principles and technique in solving a new problem. While the advantage in favor of the *demonstration method* is small, it is very significant.

2. "The *individual method* tended to be superior in those experiments that are especially difficult to perform or in which great care needed to be taken to see the exact procedure. Such facts suggest that the most effective method depends upon the nature of the experiments themselves and suggest the need for scientifically classifying them.

3. "When the *demonstration method* gives equal or superior results, it is to be preferred to the individual laboratory method because it saves about ½ the time usually devoted to performing the experiments, and permits the instructor to use the time thus saved in relating the facts and principles to allied phenomena. Furthermore the enthusiasm of the class working together is most valuable.

4. "New problems involving principles and technique already learned arouse much interest and enthusiasm, and offer the opportunity for rich returns in teaching.

5. "The results of the experiment suggest that in the smaller high schools at least, better teaching would result and much money would be saved if the laboratories could be arranged and equipped so as to facilitate the *demonstration* of many of the experiments instead of trying to provide apparatus for the individual performance of all of them."

STUDY NO. 20L

Laboratory Methods in High School Science

By J. L. Cooprider*

Problem.—To discover the relative retention values of four methods of presenting laboratory exercises in high school science: (1) *demonstration with oral instruction;* (2) *demonstration with written instruction;* (3) *individual work with oral instruction;* (4) *individual work with written instruction.*

Method.—Twelve typical laboratory exercises in high school biology were given to 68 Sophomores divided into four sections, about equal in number and native ability. Each of the four sections worked each exercise by a method different from that followed by any other group with the same experiment, but the methods alternated so that each class performed three exercises by each method.

In the demonstration work, the exercises were presented by the instructor; in the individual work, the experiments were performed by the pupils. Oral instructions, whenever

* *School Science and Mathematics,* June, 1923. Vol. XXIII, pp. 526–530.

given, were read by the instructor; written instructions, whenever given, were placed in the hands of each pupil in typewritten form.

Both the oral and the written instructions were given before the exercises were performed, but the typewritten instruction sheets were collected after the exercise began. No discussions were permitted while the instructions were being given or while the exercises were being performed and written, and no discussion relating to the exercises was permitted after they had been written, until after the test one month later.

In making the record of each exercise, each pupil filled out incompleted sentences given him after the exercise was performed; one month later the same incompleted sentence forms were given the pupils who were asked to fill the blanks as nearly as they could in the way they originally had. Both records were scored on the same basis.

The record consisted of (1) "object"—statement of the purpose; (2) "procedure"—the record of things done in working the experiment; (3) "results"—the record of observations made by the pupils; and (4)"conclusions"—a summary of facts proved, tested, or learned. "A total score for each student was determined by dividing the sum of per cents by four." For delayed recall "the per cent score made one month after the exercises were performed was divided by the original per cent in order to determine the per cent of the original scores that were retained after one month."

Findings.—(1) On the basis of the original scores, the averages with *oral instructions* were somewhat higher than with written instructions, both for *demonstration* and *individual* instructions. For immediate recall, "*oral instruction* gives better results than written instruction."

For immediate recall, "*demonstration work* seems to be more effective than individual work."[1]

2. For delayed recall (after a month had elapsed) *demonstration work with oral instructions* proved more efficient than demonstration with written instructions.

For delayed recall, *individual work with written instructions* proved more efficient than individual work with oral instructions, but the advantage of the *demonstration work with oral instructions* over the individual work with oral instructions (3.11 per cent) was about equal to the advantage of the *individual work with written instructions* over the demonstration work with written instructions (3.82 per cent).

3. A comparison of the original scores with the scores made one month later would seem to show that:

"*Demonstration work* should be given *with oral instruction*";

"*Individual work* should be given *with written instruction*";

"*Individual work* should be given in preference to demonstration work."

General Conclusions.—"If our purpose in laboratory exercises is to meet *immediate* needs, it would seem that *oral instruction* should be given in preference to written instruction. This would eliminate the class use of laboratory manuals in high school science. Also, *demonstration work* should be given in preference to individual work.

[1] The experimenter says, "The average for the demonstration work with oral instructions is (65.16–64.17) 0.99 per cent higher than the average for the individual work with oral instructions . . ." This statement is directly contradicted by the data in the table which gives demonstration work with oral instruction 64.17 per cent and individual work with oral instruction, 65.16 per cent. The claim for a 3.31 per cent advantage of the demonstration work with written instructions over the individual work with written instructions, however, agrees with the data in the table.

This would eliminate the amount of time required to do individual work, since more work can be done in the same amount of time by the *demonstration method.* The *demonstration* would also eliminate the added expense necessary to equip and supply laboratories in order to do individual work."

"On the other hand, if we wish our students to *retain* the laboratory work, it appears from this study that *demonstration work* should be given *with oral instructions* and the *individual work with written instructions.* Also, *individual work* should be given in preference to the demonstration."

STUDY NO. 21L

The Size of Classes and the Teaching Load

By C. O. Davis*

UNIT I

Problem.—To determine the teaching efficiency as indicated by an analysis of the recorded term marks (in science) given in small sections (under 20 pupils), medium sections (20 to 30 pupils), and large sections (over 30 pupils).

Method.—The Commission on Secondary Schools in 1922 secured the voluntary cooperation of the principals of

* *Proceedings of the Twenty-Eighth Annual Meeting of the North Central Association of Colleges and Secondary Schools, Part I*, 1923. pp. 30–56. Only such portions of this study as relate to the teaching of science are here summarized. A report of the same study under the title, "Size of Classes and Teaching Load in the High Schools Accredited by the North Central Association," is found in *The School Review*, June, 1923. Vol. XXXI, pp. 412–429.

approximately 100 high schools ranging in size from very small to very large, and distributed fairly equally over all sections of territory covered by the North Central Association. The marks recorded in the principal's offices during the first and second semesters of the school year, 1921–22, were analyzed to determine the percentages of pupils receiving A, B, C, D, and E marks.

Findings (with respect to science only).—(1) Considering the first two marks, A and B combined, "the order of advantage is small, large, medium sections."

2. Considering only the percentages of low marks, the best size class for science is large.

UNIT II

Problem.—To determine the teaching efficiency as indicated by term marks made by pupils in small, medium, and large classes organized into controlled groups.

Method.—Classes in about 20 cities well distributed in size and geographical location were organized definitely into small, medium, and large sections. "Care was taken to secure comparable intelligence and achievement conditions in these sections. For nine weeks, or ½ semester, these comparable groups were, so far as possible, given identical instruction." Tests were given at the end of the period.

Findings (with respect to science only).—(1) ". . . large sections seem to be most unsatisfactory of the three types, there being fewer A's, fewer A's and B's, fewer C's, and more D's and E's gained in them than are gained respectively in either of the other size classes."

2. ". . . the small section . . . appears to have no appreciable advantage over the medium sized class."

STUDY NO. 22L

The Technique and Value of Project Teaching in General Science

By Ralph Knupp Watkins*

Problem.—To determine whether project teaching secures as good results with pupils in general science as the traditional types of teaching.

Method.—The work was begun in 1920 with 25 pupils in the University of Missouri High School. "The pupils were told that the classroom was a workshop, laboratory, and study in which they could attack any of their own problems that fell within the field of general science. Material and books were furnished for working out these problems. No attempt was made to organize the problems around a central theme. There was no predetermined sequence."

The following procedure was observed: Each pupil or group of pupils after deciding upon a problem for work and study, reported their selection to the teacher whose approval of the problem must be secured before the work was begun; if the teacher did not approve, the pupil proposed an alternative problem. The pupil next made a plan and list of materials needed. The pupil kept on four by six cards a running record of his project, giving his problem, materials used, books read, the time spent, and his own statement of what he gained from the work. Pupils who did not propose a project had problems assigned them by the teacher; there was kept a clear distinction between the pupils' projects and these assigned problems.

* Doctor's thesis. *General Science Quarterly*, May and November, 1923, and January, 1924. Vol. VII, pp. 235–256, and Vol. VIII, pp. 311–341 and 387–422. Only such portions of this thesis as relate to the learning study are here summarized.

A list of 150 projects obtained from this work became the nucleus for the project work during the regular session of 1920–21. Finally in three years, a list of 221 weighted projects had been built up. An elaborate and definite technique to guide the teacher in carrying on the project work was developed including (1) management of class routine; (2) selection of new projects; (3) management of project work; (4) management of pupils; (5) handling equipment; (6) management of field-trips.

The project classes were taught in this way by five different teachers during three years. No books were used as texts but all the science books in the library were made available to the classes in general science. The pupils in the experimental classes were in the seventh, eighth, and ninth grades; one class was composed of pupils in all three grades. The classes were of normal size (about 24) ranging in age from 12 to 22. All the science classes, except the experimental class which met single periods during the winter term of 1920–21, had double 50-minute periods daily. These periods were used for laboratory work, for study, conference, or discussion as the nature of the work in hand demanded. Neither outside work nor home study was required of the general science classes under experiment.

Ten first class high schools, all but three fully accredited by the North Central Association, were chosen for comparison with respect to the general science classes. The classes in general science in these schools were taught by 12 teachers, all but one of whom were college graduates; their average number of years teaching experience was greater than that of the teacher conducting the experiment in the University High School, and they had available on the average at least as good laboratory equipment as was available in the University High School.

All the cooperating high schools used text-books. The University High School pupils had a decided advantage in library facilities, "but a reference system is inherent in project work."

The cooperating classes were with few exceptions made up of ninth grade pupils, more mature on the whole than the pupils in the experimental classes in the University High School. In every case the median intelligence scores for the classes in the University High School were lower than those of the classes in the cooperating schools. These classes ranged in size from 15 to 30. All the cooperating high schools followed the program of three single recitation and two double 40-minute laboratory periods per week; the single periods were used for recitation and the double periods for individual work or demonstration by the teacher.

Outside preparation was required, thus making the time spent in the cooperating high schools a minimum of $9\frac{2}{3}$ hours per week (assuming one hour period per day the minimum out-of-class preparation) as against $8\frac{1}{3}$ in the University High School. The data concerning conditions in the cooperating schools were secured from direct observation and interviews with the general science teachers, from a questionary sent to all the general science teachers, and from the reports of the state high school inspector.

To test results, a test was made by analyzing eight text-books published from 1915 to 1920; only topics common to seven text-books were used. The test once constructed was analyzed question by question to ascertain the extent to which it measured results in terms of commonly accepted aims;[1] it was found that it chiefly measured the acquisition of a fund of information about nature and science and the securing an understanding of everyday environment.

[1] Study No. 29C.

Approximately 50 per cent of the questions measure both aims.

The validity of the test was further tested by comparison of the subject matter with the material study by C. M. Howe,[1] also by taking correlations between the teachers' rating and scores on the general science test for pupils in the general science class in the Unversity High School for 1921–22, and for pupils in general science classes in four cooperating high schools. This correlation was found to be substantial (between +.4 and +.7).

The reliability was determined by giving the test to two groups of 37 and 38 high school pupils not included in the study of results and repeating the test with these in two weeks. The correlation was found to be +.62. "The relative weighting of the various exercises and questions in the test was entirely arbitrary." "Convenience in scoring exerted more influence [in determining this weighting] than any other factor." The scoring was done with a key.

The tests were administered in the fall and again in the spring. The comparisons were made by growth ratios for the various schools found thus: (1) The total growth for each class was divided by the number of months between the general science tests, and this quotient was multiplied by nine to get the total growth for the school year for that class; (2) the total year's growth for all classes was added; (3) the total number of pupils was found by adding the number of pupils in each class; (4) the sum of the years' growths for all classes was divided by the total number of pupils to get the mean year's growth; (5) the sum of the intelligence scores for all pupils was found; (6) the total of intelligence scores was

[1] C. M. Howe, "Can and Should General Science be Standardized," *School Science and Mathematics*, XIX, 248–255.

divided by the number of pupils to get the mean intelligence score; (7) the mean year's growth was divided by the mean intelligence score to get the mean growth ratio.

Findings.—(1) "Pupils engaged in project work do as well in reaching commonly accepted aims of general science, as measured by the general science test used in this study, as pupils engaged in the traditional text-recitation-laboratory work."

2. "Taking intelligence into account, pupils engaged in project work 'grow' more in general science, as measured by the general science test, than pupils doing traditional text-recitation-laboratory work (growth being measured in terms of gain for a given period in the two commonly accepted aims for general science teaching)."

3. "Regardless of comparative intelligence, the classes in which project teaching is used 'grow' more on the average in general science than the average class in which text-recitation-laboratory teaching is used.

4. "Measured by standards set up, established, and commonly accepted by the schools engaged in text-recitation-laboratory work, the classes of students carrying on project work do as well as, or better than pupils actually engaged in such text-recitation-laboratory work.

5. "For a school year and for classes taken as a whole, particular projects carried out by any individual pupil have little effect upon results obtained in terms of commonly accepted standards, since pupils carrying on miscellaneous groups of projects secure as much information as those following logically or 'psychologically' organized text-books."

6. The experimenter is convinced that it seems probable that project teaching insures attainment of more aims, gives a greater possibility of learning in general, should induce better learning "growth," insures increased expendi-

ture of effort on the part of pupils, develops greater initiative and independence, gives greater opportunity for "socialization," teaches pupils to think for themselves and develops the "problem solving attitude," encourages a wider range of reading, provides better for the needs of pupils of varying capacities, and provides better opportunities for real and genuine teaching, and for teacher growth than in traditional types of teaching.

STUDY NO. 23L

Laboratory Methods in Natural Science Teaching

By Harry A. Cunningham*

Problem.—To determine the relative values for dull and bright pupils of *individual laboratory work* and the *lecture demonstration method* with respect to immediate recall and retention.

Method.—Two investigations were made; in the first, two practically equivalent classes of high school Sophomores in botany, equated on school grades and scores in the Chicago Intelligence Test were the subjects. The second investigation was carried on with 10 pupils in one class period paired on the same two bases with 10 pupils in the other. Thirteen experiments suitable for both methods were used in the first experiment, and 12 in the second. Four experiments used in the first were dropped in the second and 3 new ones were substituted.

Three classes of exercises were given: (1) those in which the purpose is to clarify the pupil's concepts and give him

* *School Science and Mathematics*, October and November, 1924. Vol. XXIV, pp. 709–715 and 848–851.

new concepts through observation, but in which no problem arises and no reasoning to conclusions is necessary; (2) those which give rise to a problem the explanation of which depends upon knowledge which the pupil does not possess and which is furnished him; and (3) those in which the pupil must not only observe but must reason to his correct conclusions unaided.

Each experiment was given to one section as a *lecture demonstration* and to the other as *individual laboratory work;* each section alternated the methods on succeeding experiments, doing therefore half of the experiments by each method.

"In the *individual laboratory work,* the pupils were given specially prepared mimeographed directions and apparatus for the experiment but were given no further help. In the *lecture demonstration,* the instructor followed the mimeographed directions verbatim. The same apparatus was used with both methods except that in some cases the demonstration apparatus was larger."

Each exercise except those demanding no reasoning, was written up under three heads: (1) a statement of what was done; (2) a description of what happened; and (3) an explanation of why it happened. The pupils and the instructor were timed on 10 exercises of the first study and 11 of the second.

In scoring, a list was made of all the different points made by all the pupils under all three divisions of the experiment and each individual was scored in each of the three divisions and on the experiment as a whole, on the basis of this list. These point scores were turned into per cents by dividing the number of points made in any division by the possible number of points that might have been made. The total score was obtained by dividing by three the sum of the per

cents made by the pupil in all three divisions of the experiment. After a period of approximately one month in the first study and three months in the second, the pupils were re-tested by giving them the title of the experiment and by then telling them to write what they could remember of "What was done," "What happened," and of the explanation.

Findings.—(1) "From the point of view of economy of time, the results favor the *lecture demonstration method*," but since with several experiments the individual method required less time than the demonstration method, "the saving of time [on the average] by the *lecture demonstration* may not be enough to be of much consequence." The difference in time, moreover, was much reduced in the second investigation.

2. The immediate results on the whole favored the *lecture demonstration* in all three divisions of the experiment, the average advantages in both investigations ranging from 3.4 per cent to 8 per cent. The results were much lower in both investigations in the "explanation" division than in the other two.

3. The *demonstration method* did not prove uniformly or consistently superior with respect to the results secured for all the experiments or for individual pupils, ". . . but it is in the study of individual cases that most real value may be obtained from a study of this kind." There was a great variation in the mean scores made by the individuals under the two methods and in the relationship between immediate results and results obtained after a period of time had elapsed.

4. "Neither method seems to be any better for the slow pupils than for the bright ones."

5. On the average, it took the dull no longer to perform the experiments than the bright.

6. "The mean scores after a period of time were just the reverse of the immediate results in each of the three divisions, . . . and also in the totals" in both investigations, since "a higher percentage of the work done by *individual laboratory work* is retained."

The experimenter states that "it is not safe to make sweeping generalizations as to best laboratory methods from these data" and expresses the conviction that "no very great benefit can be gained by more group studies of this sort" unless "much attention is given to the cases which do not agree with the general conclusions" because of too many variations of individual cases which are covered up in the general results. "Much more can be gained by (1) a careful analytical study of each individual experiment to determine just what skills and abilities are necessary in mastering that particular exercise; (2) a careful testing and diagnosis on the basis of evidence obtained by the testing of each individual pupil to see if he has these skills and abilities; and (3) the adoption of such methods and technique for each individual as our study of both experiment and student indicates is best."

7. In the second investigation in which approximately three times as many days had elapsed between the performing of the experiments and the re-test as was the case in the first investigation, there is a greater difference between immediate and retention scores.

STUDY NO. 24L

A Practice Study in Paragraph Summarizing in Chemistry

By Kimber M. Persing*

Problem.—To determine the influence upon the learner, of giving definite instruction and drill in paragraph summarizing in chemistry.

Method.—Two beginning classes in chemistry, of 23 pupils each, were made experiment groups, while a third beginning class of 17 pupils, and a fourth class of 20 pupils, who were just completing the second semester of chemistry, were made the control groups. "This grouping was made because it seemed to represent the most equal distribution of the students. Intelligence scores were not available."

In an initial test administered to all sections before the beginning of the experimental work, each pupil was given a printed copy of four paragraphs, the first two on chemistry and the last two on biology (to test transfer), with directions to read all the paragraphs, then to re-read each paragraph in turn and summarize it in a sentence of about 10 or 12 words, writing this sentence in the space provided. The initial test papers, unread, were labeled and filed for scoring later. "The experiment groups then were given instruction and practice in paragraph summarizing"; time was taken out of the regular recitation period for this work.

The actual time spent in this drill was 12 five-minute periods, extending through three weeks, during which time daily assignments were the same in all three beginning classes. Group B, the advanced class, was of course doing

* *School Science and Mathematics*, June, 1924. Vol. XXIV, pp. 598–604.

a different type of work. "The material used for drill purposes was selected from the daily assignments or review portions of the text."

No reference was made during the experiment period to the initial tests and the daily assignments did not involve the materials of the first two test paragraphs.

At the end of the drill work, the initial test was again administered to all groups as a final test. The papers were labeled and filed for scoring with those of the initial test. The first scoring was on the basis of comparison; plus or minus values were assigned upon the improvement or loss in the statement of the final answer as compared with the original answer.

Since these results showed very little change in pupil performance, the papers were rescored on a different plan: Each answer from a given test was copied separately on a small card, and these cards were then classified and sorted into groups by three persons independently. The cards could then be sorted into four groups, from each of which four or five typical answers were selected.

These answers, having received unanimous classification, were adopted as a key or scale, which was thus made up of four divisions or groups, each consisting of four or five types of answers. To each group in the scale was assigned a numerical value ranging from 0 to 3. After all marks from the first scoring had been removed, and the papers thoroughly intermixed and so arranged that the pupil's name and section number were not visible to the scorer, they were all scored a third time. On the assumption that a perfect score was a possibility with respect to each paper, the percentage scores were calculated by the formula,

$$\text{Percentage score} = \frac{\text{Total points} \times 100}{\text{Number of papers} \times 3}$$

Findings.—(1) While the initial tests of the different sections were fairly uniform by both plans for scoring, "there is fairly clear evidence [presented in a series of tables] that training in summarizing as applied to chemistry means a very decided improvement in learning efficiency."

2. Improvement in the ability to summarize one type of subject matter was found to carry over to other types.

STUDY NO. 25L

Extensive Reading of General Science as a Means of Increasing Knowledge of Scientific Facts and Principles

By Francis D. Curtis*

UNIT I

Problem.—To determine whether extensive reading of general science increases the amount of knowledge of scientific facts and principles when the extensive reading is given as an extra course outside of the regularly scheduled program of studies.

Method.—Two libraries of about 40 books each were selected from 347 scientific books, none of them text-books, all widely variant in subject, treatment, style, reading difficulty, etc. Each book was expected to contribute in some degree to the satisfaction of the interests of children and adults,[1] to the training needed for a reading of science in the newspapers,[2] and to afford some training in scientific attitudes, previously defined in the study.

* Doctor's thesis. *Some Values Derived from Extensive Reading of General Science*, Contributions to Education No. 163. New York: Teachers College, Columbia University, 1924. pp. 50–112.

[1] Study No. 44C.

[2] Study No. 43C.

The titles in each of the two libraries were divided roughly into seven classifications, "to serve as a guide to the pupil, with the hope that he would sample various classes rather than devote his time to the books in the first class he happened to find attractive." For the pupil-reader's guidance a card was placed in the pocket on the inside cover of each book, giving the group and individual number of that particular book in the list, a brief paragraph stating frankly the nature of the book, and several brief guides with page references to passages; it was hoped that these would catch the pupil's interest and at the same time give him a more accurate idea of the nature of the book than that conveyed in the paragraph just mentioned.

One of these two libraries was made the basis of each of the three units of this investigation.

Forty-five eighth grade boys in a six-year boys' secondary school in New York City met with the experimenter one period per week, 10½ class periods in all, over a period of about three months. These class meetings were not for the purpose of teaching the subject matter of general science; there was no attempt made to teach the facts of general science other than such as incidentally came up as a part of the experimenter's principal purpose, which was to stimulate in all possible ways the *voluntary* reading, as extensive as possible, of the books in one of the special libraries of scientific books described above.

After six meetings the less interested half of the class was eliminated from experiment group A to serve as a control along with two other controls, the seventh grade class of 30 boys, and the regular ninth grade class in general science of 59 boys. Of these four groups, only the ninth grade control had had regular work in general science and this group was taking the regular course in general science under

their regular instructor. The experiment group was paired with each of the controls on the basis of Brightness Quotient and at the end of the experiment period, all groups were given the Dvorak S–2 "General Science Scales."[1]

Findings.—(1) ". . . at the end of the experiment period the experiment group was about the equivalent of nine months' uninstructed development (figured on the basis of Dvorak's annual increase norms) nearer the average of the ninth grade group, paired with it on the basis of Brightness Quotient, than would be normally expected; its average was more than half a year farther ahead of the seventh grade group paired with it, than would be expected from the extra year's maturity of growth and experience, and nearly a whole year beyond the development of the portion of the eliminated eighth grade group paired with it, over whom the experiment group would normally be expected to show no superiority."

". . . it seems reasonable to conclude, [therefore] that [extra-curricular] extensive reading of general science contributes materially to the store of general scientific information."

2. ". . . extensive reading probably tends to increase the variability with respect to knowledge of general science within the group."

UNIT II

Problem.—To determine whether extensive reading of general science increases the amount of knowledge of scientific facts and principles when substituted for part of the work usually required in the course in general science.

Method.—Experiment group B consisted of 19 ninth-grade girls in a six-year private girls' secondary school in

[1] These tests were not available at the beginning of Units I and II

New York City. The control group was the other ninth grade section composed of 18 girls. The experiment group met the experimenter during one of their three regular periods for general science each week, 9 periods in all over a period of about three months; the other two periods for general science each week were spent with their regular instructor, who met the control group three periods per week. Thus the work intended to stimulate in the experiment group the desire to read science extensively, was substituted for one of the regular periods for instruction in general science.

The experiment was conducted as in Unit I. In this experiment also, pairing was made on the basis of "Brightness Quotient" but at the end of the experiment period, achievement of both groups was measured with the Dvorak S–2 and T–2 Forms of the "General Science Scales" combined.

Findings.—(1) ". . . during the experiment period of about three months, the . . . experiment group gained on the control group practically half a year's progress in general scientific information, as measured by the combined two forms of the Dvorak Scales."

2. Here as with the boys in Unit I, the extensive reading apparently increased the variability within the group.

UNIT III

Problem.—To determine whether extensive reading of general science increases the amount of knowledge of scientific facts and principles, when given in addition to all the work regularly required in the course in general science.

Method.—For the third phase of the investigation, experiment group D was one of three ninth grade classes in the second term of general science under the same teacher

in a medium-sized, public, co-educational high school in New York City. A composite control was made up of the members of the other two classes. Class work for the test and control groups was identical; no additional factor was added to the class work by the experiment, but the test group alone had access in their school library to the selected library of scientific books which had formerly served group B.

There were no reading requirements whatever, but the teacher represented the reading of the special library as a very great privilege to the favored class, who forthwith made the most of their opportunities. Pairing was done on the basis of the initial scores in the Dvorak S–2 test administered to all three classes 10 *days after* the beginning of the experiment.

At the end of six weeks, the group which was in the teacher's judgment the poorer of the two control groups used with the first experiment in this school, was made experiment group E, which was to have the exclusive privilege of reading the special books for five weeks, while the remaining class which had not had access to the books, became the control. The Dvorak T–2 which had been the final test for group D became the initial test for group E, and the S–2 test, administered again at the end of five weeks, became the final test. As a further check upon the results of the experiment, the A-Form of the Ruch-Popenoe "General Science Test" was given group E and its control at the beginning of the experimental period, and the B-Form at the end. Another pairing was made upon the basis of the initial S–2 Test administered three months before the final administering of the same form, and six weeks before the experiment with group E began.

Findings.—(1) The experiment with group D failed to show definitely conclusive results because of an unavoidable cutting short of the class-period during which the final test was administered. But "translated into achievement growth, in accordance with the computed annual increase, . . . the pupils in experiment group E gained on the average more than eight months in the space of about six weeks (measured by the Dvorak growth in achievement norms) during which they were permitted to use the special library of scientific books." With respect to the results measured in terms of the Ruch-Popenoe Test, the average gain of the experiment group over that of the control during the space of six weeks was 19.4 per cent of the entire *final average score* of the control group.

General Conclusions from the Three Units and from Supplementary Data.—(1) The conclusion seems justified that extensive reading functions in adding to the pupil's achievement in general science, whether this reading be done entirely apart from any course in general science, or as an integral or a supplementary part of the regular course in general science.

2. A study of individual records shows that "pupils given proper encouragement and access to suitable books and magazines will read a great amount of scientific literature for recreation along with their regular school work."

3. "An effective means of providing in the course in general science for individual and sex differences is through the medium of extensive reading."

4. "Extensive reading of scientific literature stimulates the desire of some of the pupils to proceed further with the study of science in the school."

STUDY NO. 26L

An Experiment in Developing Scientific Attitudes in Eighth and Ninth Grade Pupils

By Francis D. Curtis*

UNIT I

Problem.—To determine whether effective training in scientific attitudes can be given pupils in the eighth and ninth grades.

Method.—The experimenter first analyzed the philosophical scientific literature in order to secure a list of scientific attitudes. This list was submitted for criticism and suggestions regarding deletions and additions, to 100 teachers of science in high schools and universities, and a final list of scientific attitudes was constructed in the light of the composite reactions given. A group "Test of Scientific Attitudes" was then constructed to measure the scientific attitudes of this reconstructed list.

Parts of 6 meetings with group A (Unit I[1]), in all about two hours' time, were devoted to definite training in scientific attitudes, of which training the eliminated section received a small part. "Newspaper clippings containing false deductions, problems with insufficient or superfluous data, discussions of superstitions, incompleted demonstrations of experiments permitting prediction of possible solutions, and reports upon inventors and other scientists who were forced to struggle for their success against prejudice and narrow-mindedness, were introduced and dis-

* Doctor's thesis. *Some Values Derived from Extensive Reading of General Science*, Contributions to Education No. 163. New York: Teachers College, Columbia University, 1924. pp. 50–112.

[1] Study No. 25L.

cussed fully by the experimenter and the class." *Four months following the end of the experiment period and six months after the dividing of the experiment group*, the "Test of Scientific Attitudes" was administered to both sections, and to the seventh and ninth grade controls as well. It will be remembered that these ninth grade boys were just completing a year's work in the regular course in general science. Pairing of group A and the three control groups was on the basis of Brightness Quotient.

A few minutes of each of the 9 periods during which the the experimenter met with group B (Unit II[1]) were devoted to discussion and training in some phase or phases of the scientific attitudes as with group A, but the total of time expended in this work with group B was about the same as that with group A. At the end of the experiment period the "Test of Scientific Attitudes" was administered to group B and its control; pairing was on the basis of Brightness Quotient.

Correlations were made for experiment and control groups in schools A and B, between Brightness Quotient and possession of scientific attitudes as measured by the experimenter's test.

As a further check upon the possession of scientific attitudes the experimenter's test was administered to a class of 28 graduate students in Teachers College, a highly selected group who were taking work in the pedagogy of high school science; many, moreover, had previously had considerable experience in teaching high school science.

Findings.—(1) Of a possible score in the "Test of Scientific Attitudes" ranging between +95 and −97 points, group A scored an average of 12.25 points higher than the eliminated half of the eighth grade, which in turn scored an

[1] Study No. 25L.

average of 3.6 points above the ninth grade class completing the regular course in general science. The ninth grade class scored only an average of 2.45 points above the seventh grade control group. Group B scored 24.55 points on the average more than its control. "The conclusion seems justified that a little instruction in scientific attitudes pays large dividends . . ."

2. The graduate group scored in the "Test of Scientific Attitudes" an average of only 11.7 points above the average of group A and only 3.1 above the average of group B. This relatively slight superiority of the graduate group in the possession of scientific attitudes as measured by the test, over the experiment groups trained specifically in the scientific attitudes would seem to indicate that extensive training in scientific subject matter, even when joined with superior intelligence, maturity, and more or less extensive experience in teaching science, does not in itself insure the degree of possession of scientific attitudes which may be secured with definite training toward this end.

3. "The further conclusion seems justified, at least to the extent indicated by this experiment, that training in scientific attitudes is not immediately lost, but remains to a considerable extent for some time [in the case of group A, four months and of the eliminated half of the eighth grade, six months] after the training is given."

4. A positive correlation was found between Brightness Quotient and scientific attitudes as measured by the test, "but data from this experiment are too meager and because of the small number of cases the probable error is too high, to justify definite conclusions regarding how high the correlation between these factors probably is."

UNIT II

Problem.—To determine whether ordinary class-work in general science is in itself effective in training pupils in scientific attitudes, and whether the recreational reading of scientific books, extrinsic to the regular work of the course in general science, in itself gives training in the scientific attitudes.

Method.—The "Test of Scientific Attitudes" was administered to a composite test group DE, made up of members of the two groups D and E (Unit III[1]), and their control group. As was the case with groups A and B, this experiment group was doing extensive voluntary recreational reading of scientific books, but no attempt whatever was made by their teacher to teach scientific attitudes, as such, to any of the groups to an extent greater than her usual practice while conducting her regular classes in general science. Whatever the experiment group may have gained in the scientific attitudes, therefore, may be reasonably attributed to the experimental factor, extensive reading. Pairing was on the basis of initial scores on the Dvorak S-2 "General Science Scales."[2]

Findings.—(1) The composite test group DE scored 5.0 points on the average above the average of the control. "The conclusion, therefore, seems justified that extensive reading of general science apparently of itself serves to give some training in scientific attitudes; but such gains as may thus be secured are inconsiderable as compared with those made when definite instruction in scientific attitudes is given."

2. The relatively low scores, in schools A and B as well as in this school, of the ninth grade controls (as compared

[1] Study No. 25L.

[2] Intelligence Quotients or Brightness Quotients were not available.

with the experiment groups, as measured by the test) who were taking the regular course in general science but who were not receiving any special training in scientific attitudes, indicates that scientific attitudes (as measured by the test) are not developed by ordinary class work to an extent comparable with that secured by devoting a small amount of time to definite instruction in the scientific attitudes.

PART III

The Curricular Studies

STUDY NO. 1C

Children's Interests in Nature Materials

By Gilbert H. Trafton*

Problem.—To test children's knowledge of animals and plants, and "to see nature from the child's standpoint."

Method.—A little less than 1000 children in the four upper grades, the fourth, fifth, sixth, and seventh, of the Passaic, New Jersey, public school, answered the following sets of questions:

Set 1.—(1) Make a list of all birds, insects, and other animals that you have seen living in Passaic. (Do not name animals that you may have seen in a menagerie). (2) Describe briefly the one most noticeable thing about each.

Set 2.—(1) Which animals do you like best? Tell why. (2) Are there any animals living in Passaic which you dislike? What are they? Why do you dislike them? (3) Write the most interesting thing you know about any animal.

Set 3.—(1) What interests you most about a plant? (2) (a) Make a list of the trees that you know. (b) Make a list of flowers that you know. (3) Which flower do you like best? Why?

Set 4.—(1) What animal after man knows most? Give reasons for your answer.

* *The Nature Study Review* (Comstock Publishing Company), September, 1913. Vol. IX, pp. 150–160. This article in *The Nature Study Review* is a reprint of the original report of the investigation which appeared in a local publication of practical studies in the Passaic public schools, 1904. A brief digest is found in the *Third Yearbook*, Department of Superintendence, N. E. A., 1925. pp. 299–300.

Findings.—Set I.—(1) ". . . sounds (chiefly songs) appeal more to the girls than to the boys and the contrast between the sexes increases with age."

2. ". . . breeding habits, modes of locomotion, and habitat appeal more to boys in every grade, and in general, the activities of animals appeal slightly more to boys."

3. ". . . color and size impress the lower grades more than they do the higher grades."

4. ". . . in the three upper grades, the activities of animals appeal much more strongly to children than does mere appearance; and in the lower grades it is still an important factor. The more prominent activities mentioned referred to feeding habits, modes of locomotion, habitat, and sounds made."

5. "In the lower grades, there was a marked correlation of ideas of size with color and of locomotion with habitat," indicating that quite likely "this represents the limit of children's knowledge." "In the higher grades there was very little of this correlation."

Set 2.—(1) The favorite animals in order of the frequency of mention were dog, horse, cat, wild birds, rabbit.

2. "Birds and cats were greater favorites with girls than with boys."

3. ". . . only one pupil, a girl, did not like any animal."

4. The reasons given for preferences in the order of frequency of mention were "usefulness, gentleness, faithfulness, intelligence, caring for people and saving life, pleasing appearance.

5. ". . . pleasing appearance [in animals] appealed more strongly to girls than to boys, and more to the lower than to the higher grades."

6. "Usefulness and faithfulness [in animals] appealed more to the boys, and the saving of life to girls."

7. "In the higher grades less attention was given to the practical consideration."

8. The animals disliked in the order of frequency of mention were "mice and rats, snakes, cats, dogs, mosquitoes, pigs."

9. "One fifth of the children, 60 per cent of them boys, wrote that there was no animal they disliked."

10. The reasons for disliking certain animals, given in order of frequency of mention were: They injure people, cause annoyance, have unpleasing appearance, decrease our food supply, and are unclean. "The great reason assigned was that animals do some personal harm" in all gradations from cat-scratch to "the supposedly deadly" snake-bite, "but this fear was less prominent in the upper grades."

11. The most noticeable feature in this set of answers was the groundless reason given for disliking wild animals, chiefly snakes, that they are poisonous. "Children should at least be taught the truth regarding the human relations of these ill-treated animals, many of which are of economic value in destroying insects."

12. In the descriptions of "the most interesting thing," the animals in order of frequency of mention were dog, horse, squirrel, monkey, cat, wild birds.

13. The interesting characteristics in order of frequency of mention were intelligence, usefulness, appearance, devotion to humans in saving lives, and the ability to sing.

14. Again the practical value was found to appeal more to boys and aesthetic value (song) more to girls.

Set 3.—(1) The interesting features concerning plants in the order of frequency of mention were flower (57 per cent of the answers), growth of plant (15 per cent), leaf

(8 per cent), bud (3 per cent). There was practically no difference in the tabulation of these replies comparing either ages or sexes.

2. "The total average shows 61 per cent of trees known are wild, while in the case of flowers, the ratio is just about reversed, the wild forming 41 per cent and the cultivated, 59 per cent."

3. In the lower grades lists of both trees and flowers were about equally divided between wild and cultivated varieties, but in the higher grades, the per cent of wild trees was larger, while that of wild flowers was smaller than the per cents respectively of cultivated trees and flowers.

4. The lists of favorite flowers indicated that the children were unable to distinguish between different kinds very closely, since to the children the great majority of the flowers were roses.

5. The two things about flowers that appealed to the children were fragrance and color; in many cases both characteristics were named by the same child. Appearance, chiefly color, was mentioned on an average in 45 per cent of the responses from all the grades investigated and from both sexes, and fragrance was mentioned on an average in 49 per cent.

Set 4.—(1) The animals in the order of frequency of mention as being most intelligent were dog, monkey, parrot, wild birds. "The animal chosen seemed to depend to some extent on the grade; the horse, for example, appealed less to the higher grades, its place being taken by the dog."

2. The reasons assigned for considering the various animals intelligent were: Their ability to perform tricks (28 per cent), to understand what is said to them (21 per cent), to care for people and to save life (18 per cent), to perform acts similar to man's (10 per cent), to remember

(6 per cent), and to avoid danger (3 per cent). The ability to save life and to understand the human language was found to impress the girls more than the boys; the ability to perform tricks was found to appeal more to boys.

General Conclusions.—(1) The limited acquaintance of children with wild plants and animals stands out prominently. "The average number of wild animals named was 11; of domestic animals, 7; cultivated trees, 4; wild trees, 6; cultivated flowers, 6; wild flowers, 3."

2. In adapting the subject matter of nature study to children, the interest, as for example, that in color and size, must serve as the entering wedge leading to the study of living things from the standpoint of their life activities, through which interest may be maintained and increased. In this study as the children came to know more about animals they showed a tendency to be more impressed by habits and other activities, a fact which indicates the line along which the interest of the child is to be chiefly aroused.

STUDY NO. 2C

Some Experiments with Regard to the Relative Interests of Children in Physical and Biological Nature Materials in the Kindergarten and Primary Grades

By Laura Emily Mau*

Problem.—To determine the different attitudes children take toward three phases of nature materials, plant life,

* *The Nature Study Review* (Comstock Publishing Company), November, 1912. Vol. VIII, pp. 285–291. A brief digest is found in the *Third Yearbook*, Department of Superintendence, N. E. A., 1925. pp. 298–299.

animal life, and physical nature, as a basis for determining factors of help in the selection of the work for the different grades. To determine (I) what is the relation of age and sex to the kind of object preferred; (II) what are the cardinal factors in determining the preference; (III) what are dominant interests in each phase of the material in the different grades.

UNIT I

Method.—The subjects of this investigation were 1988 children in four grades, the kindergarten, first, second, and third grades, in nine representative schools in and about Chicago. The children were shown (1) a pepper plant with many red berries on it, (2) a gray cat, and (3) a toy engine about eight inches long and five inches high with very complete works, and were asked, "If you could choose one of these three things for your very own, which one would you choose? Why? Now you may ask any question which you would like to ask about any of these things."[1]

Findings.—(1) "There is a marked increase in preference for the cat, both for boys and girls from kindergarten to grade three in all schools."

2. "There is a decline in preference for the engine for both sexes especially marked between grades two and three, and the decline for the girls is very rapid."

[1] Professor Elliot R. Downing in the *Third Yearbook*, Department of Superintendence, 1925, gives, relative to this study, the following information, which is not included in the report by the investigator:

For each experiment the objects were taken into the room and placed on the teacher's desk. Replies to the question, "Which would you choose?" were whispered to Miss Mau or her assistants and recorded.

3. "There is very little variation from kindergarten to grade three in plant interest, with a rise in grade one for the girls."

4. "Both from the standpoint of questions and number of children that asked questions about the engine, boys far exceed girls in all grades, with a marked decline for both sexes from the kindergarten to grade one and from grade two to grade three.

5. "There is a marked increase in preference for the cat as shown both by numbers and number of questions for both boys and girls from the kindergarten to grade three in all schools.

6. "There is very little variation from the kindergarten to grade three in plant interest, with a rise in grade one for girls"; ". . . the girls, both in numbers and in the number of questions asked, far exceed the boys in all grades with a striking rise in grade one.

7. "So far we can say that there is a rising interest in the cat, a waning interest in the engine, and a very little variation in the plant from kindergarten to grade three. The younger the child the greater the preference for the engine [over that for the cat and the plant]."

UNIT II

Method.—This investigation was carried out with the same schools and grades; responses were received from 2085 children. The materials used were (1) a sensitive plant, (2) a turtle dove in a cage, and (3) two bar-magnets and iron filings. The children were allowed to take an active part in the experiment, that is, they fed the bird, touched the sensitive plant so that its leaves suddenly closed, and picked up the iron filings with the magnet. Then after a large number of children had participated in these activities, the

materials were taken away and a week was allowed to intervene before the experimenter returned for the questions which the children wanted to ask.[1]

Findings.—(1) "The bird is preeminently preferred in all schools in all grades for both boys and girls without any marked variation from kindergarten to grade three."

2. "There is not much variation in preference for the plant, with a slight rise in grade one; the main difference is that between boys and girls."

3. There is little variation in preference for the magnet from the kindergarten to grade three, the greatest difference being between boys and girls.

4. "The results obtained from the total number of questions asked and the number of children that asked the questions, show that the interest in the bird exceeds that in the plant, and in the magnet for the boys and girls of all grades."

5. "The number of questions pertaining to the magnet exceeds the number regarding the plant for boys in the kindergarten and grade one, and for girls in the kindergarten; questions pertaining to the plant exceed in number those regarding the magnet in grades one, two, and three for girls."

[1] Dr. Downing in his abstract adds this information to that given by the experimenter in her report:

The children gave a drink to the hungry, thirsty dove; two children held the magnets near the filings and all saw the filings jump up to the magnets. The experimenter then said she could not stay that day to answer questions, but that she would return in 10 days and answer such as they might like to ask. On her return, questions were whispered to her or her assistants and recorded. She then hastily grouped these questions and gave a talk to answer them. It was hoped that the materials less interesting to the children would fade out of their minds and that the number and kinds of questions would disclose the answers to the problems investigated.

General Summary.—". . . the interest in the bird is paramount in all grades; the interest in the cat reaches its culmination in grade three; the interest in the plant exceeds that in the cat in grade one; the climax of interest in the engine is in the kindergarten; the order of interest for boys seems to be animal life, physical material, plant life; and for girls, animal life, plant life, physical nature material."

An analysis of the questions indicates that "motor activity gradually wanes in kindergarten to grade three and the climax for sensory response appears to be in grade two." "Interest in caring for the plant and cat overtops use and function in kindergarten and grade one, and construction overtops use in kindergarten and grade one with regard to the engine." "'Beauty' as a reason for preference is far more dominant in grades two and three than in the kindergarten and grade one; use, function, and purpose appeal to the child rather than form, size, color, and arrangement. There is greater variation in the reasons for preferring the cat, showing that there are more things in the animal to appeal to the child especially in grades two and three, where there appears to be a marked increase in the animal interests."

"It was found that the dominant interests in the plant are in the growth and activities of the plant and identification. Interest in identification which is relatively slight in kindergarten, steadily increases and exceeds that in the plant activities in grade three. Care of the plant seems to rank next and exceeds use in all grades; color and geographical distribution are not mentioned before grade three."

"Those interests stimulated by the cat which are not mentioned for the bird pertain to classification, use, adaptation, and moral qualities. Those included among the bird interests which are not mentioned for the cat are identification, home, care of bird, color, geographical distribution.

The interests are in the main centered about the activities of the bird and the cat. Identification is in evidence to a striking degree in the bird and interest in it increases rapidly from the kindergarten to grade three. Care of the bird seems to claim the greatest attention in grade one; structure is not mentioned much before grade three; the naming of the bird is not mentioned before grade two, and the name of the cat only once before grade three. The added interests for the cat in grade two are classification, name, sex, sensory response, and for grade three, moral and intellectual qualities of the cat, and adaptation. The added interests in the bird in grades two and three are name and color; sex and geographical distribution have not been mentioned before grade three.

". . . from the point of view of children's questions, the animal interests exceeded all others at all ages; there was an increasing interest in animal life with advancing years and the awakening of new interests was very marked in grade three."

"The difference between the interest shown between the bird and the cat shows that there is a difference in the kind of animal that makes its strongest appeal at different ages. The difference between the interest in the toy engine and the magnet shows that there is a difference as to the kind of physical material that makes the strongest appeal at different ages."

STUDY NO. 3C

Children's Interest in Nature Materials

Elliot Rowland Downing*

Problem.—To determine whether children are more interested in animal, plant, or physical materials in nature study, and in what phases of these materials they are most interested.

Method.—A study was made of the questions and observations voluntarily written to *St. Nicholas* and published from November, 1899, to April, 1912, under the departments, "*We Will Ask St. Nicholas About It*," and "*Because We Want to Know*." It was thought that since these questions were not stimulated by any questionary, they revealed the normal interests of children somewhat better than schoolroom investigations which are conducted necessarily under somewhat artificial conditions. The questions printed represented only a fraction of those received by *St. Nicholas*, but are a more or less typical sampling. "The same question was answered in the department only three times," although questions and observations were printed from 301 boys and 441 girls. The average age of the boys who stated their ages was 11.9 years and of the girls, 12.08. There were in all 295 observations and 447 questions analyzed.

Findings.—(1) Sixty-one per cent of the material analyzed concerned animal material; 20.6 per cent, plant material; 11.6 per cent, physical material; and 1.8 per cent, miscellaneous (largely the enjoyment of beauty and the compan-

**The Nature Study Review* (Comstock Publishing Company), December, 1912. Vol. VIII, pp. 334–338. A brief summary is found in the *Third Yearbook*, Department of Superintendence, N. E. A. p. 299.

ionship of nature). Therefore the child's major interest is in animals.

2. "Boys write more often about plant materials than girls and girls more often regarding physical phenomena than boys."

3. The most frequent interests under plant material were: Wild flowering plants (36.6 per cent), trees (25.53 per cent), wild spore-bearers (16.99 per cent), garden fruits and vegetables (14.38 per cent), and garden flowering plants (8.50 per cent); under animal material: Insects (24.95 per cent), with birds only slightly less (24.27 per cent), common mammals (18.54 per cent), reptiles (9.94 per cent), invertebrates, other than spiders and insects, (7.73 per cent), fish (6.63 per cent), amphibians (3.53 per cent), spiders (2.87 per cent), human physiology and Indians (less than 1 per cent each); under physical materials: Elementary physics (42.28 per cent), geographical and geological (24.39 per cent), astronomical (16.26 per cent), photographical (6.50 per cent), mineralogical (4.48 per cent), mechanical (3.25 per cent), industrial (2.44 per cent).

4. Most of the questions on animals pertained to wild animals with only 19 pertaining to pets and 4 to horses; the maximum number of these questions seem to pertain to the forms which are most numerous.

5. Of the questions and observations in all three groups—plant, animal, and physical material—nearly $\frac{2}{3}$ pertained to *activities;* about $\frac{1}{8}$ listed under animals, $\frac{1}{4}$ under plants and $\frac{1}{5}$ under physical material pertained to *identification;* the rest were distributed in all three divisions fairly equally between *care*, *classification*, *function of parts*, and *structure*, the latter leading.

6. Many questions under plant and animal activities are of the "What, Why" form, but "seem to signify the desire

to be informed as to the causes which operate to produce the action rather than regarding the ultimate reasons in each case."

STUDY NO. 4C

Summary of a Study in Agriculture in Rural Elementary Schools

B. M. Davis*

Problem.—To determine some of the most successful subject matter units and materials of instruction for a course in agriculture "for an average school under average conditions," and to secure information regarding the relation of agriculture to other subjects.[1]

Method.—The investigator sent a questionary requesting extensive information pertinent to the teaching of agriculture, to a selected list of 500 widely distributed teachers of agriculture. Replies, for the most part very complete and often accompanied by much additional information, were received from 172 teachers in 30 states representing all sections of the country.

Findings.—(1) "Most of the topics suggested were confined to the first half of the list. The great agricultural interests, field crops, especially corn and wheat, farm animals, dairying and soils, were mentioned far more frequently than any other topics. The answers clearly indicate that the phases of agriculture meeting with the greatest success

* *The Nature Study Review* (Comstock Publishing Company), January, 1913, Vol. IX, pp. 2–13.

[1] Only those portions of this report bearing upon the topics mentioned in the statement of the problem are here summarized.

in teaching were closely correlated with dominant local farm interest."

2. "The use of home-made apparatus seems to have had two advantages, one in saving school time, and the other in carrying school interests into the home. The school-made apparatus brought more children in contact with the work, and gave the pupils the benefit of the teacher's suggestions."

3. A large majority of the teachers replying did "some field work ranging from a few hours in the spring months to 5 hours a week during the school year. Many used the time before school opened or after school closed, or recess and noon periods."

TOPICS LISTED IN ORDER OF FREQUENCY OF APPEARANCE IN ANSWER TO THE REQUEST, "GIVE LIST OF TOPICS OR UNITS THAT YOU HAVE FOUND OR REGARD AS MOST SUCCESSFUL" (DAVIS STUDY)

1. Field crops, including corn, wheat, potatoes, alfalfa, clover, barley, oats, vetches, peas, cotton, sweet potatoes, sugar cane, and tobacco
2. Farm animals, including horses, hogs, sheep, and including also stock judging and rations
3. Dairying, including Babcock test, care of milk and rations
4. Soils, including drainage, dry farming, irrigation, and texture
5. Insect enemies
6. Poultry
7. Horticulture, including budding, grafting, spraying, and pruning
8. Gardening, including school gardens, plot experiments, and growing contests
9. Weeds
10. Seed testing, including selection, and germination and purity tests
11. Birds
12. Plant studies, including a variety of phases
13. Flowers

14. Plant propagation
15. Farm management, referring especially to farm accounts
16. Fertilizers
17. Farm machinery
18. Roads
19. Bee keeping
20. Weather
21. Farm buildings
22. Plant breeding
23. Marketing

4. Animal husbandry was taught by having animals brought to school, by having reports upon animals which had been studied at home, through demonstrations by teachers at various farms, "by means of pictures and reading to be verified at home, and by demonstrations at fairs."

5. Experiments, many of them extensive individual and group projects, were performed in the school, on the school grounds, in the school garden, or at home by pupils who reported the results at school.

6. "Correlation of other subjects with agriculture may have a two-fold value, one in economy of time, the other in giving a practical turn to these subjects—especially to the formal studies such as arithmetic. All but one teacher found that instruction in other subjects was helped by correlation with agriculture. Arithmetic, language, and geography were generally specified. History, reading, nature-study, manual training, domestic science, drawing, and physiology were also mentioned."

7. In selecting topics or units for instruction, "most teachers were guided by local or community interests."

STUDY NO 5C

The Present Status of Nature-Study in the Elementary Schools

By Alice Jean Patterson*

Problem.—To determine what is the purpose, content, and method with respect to nature study in the schools.

Method.—An analysis was made of 20 state courses of nature study and 30 nature study courses of large cities, all grouped to represent the four different geographical regions of the country, the East, the South, the Middle West, and Northwest including the Pacific states.

Findings.—(1) Nature study is recognized as a school subject in both state and city courses in all parts of the country. There is considerable uniformity of purpose in the courses offered by the various states and cities, namely, to bring children into intelligent, sympathetic touch with daily life, and to train them in "a scientific attitude of mind."

2. "Plants, animals, weather phenomena and sky, physics and chemistry (including soil), are represented in all of the courses. Plants and animals constitute the major portion of the courses. On an average, 38.2 per cent of the topics in the courses examined are based upon plant life; 34.4 per cent on animals; and the remainder about equally divided between sky and weather, and physical and chemical phenomena."

3. "Plant topics arranged in the order of the greatest number of times that they appear are: trees, seeds and fruits,

* *The Nature Study Review* (Comstock Publishing Company), November, 1913. Vol. IX, pp. 239–244. A brief digest is found in the *Third Yearbook*, Department of Superintendence, N. E. A., 1925. p. 300.

wild flowers, weeds, garden plants, farm crops, fungus diseases, bacteria, plant structures, and classification."

4. "The chief animal topics [arranged in similar order] are: pets, birds, farm animals, insects, wild animals, toads and frogs, fish, reptiles, poultry, earth-worms, dairying, structure and needs of animals."

5. "The favorite topics under weather and sky [in similar order] are: the keeping of simple weather records, rainfall, winds, weather maps, movements of sun and moon, identification of a few stars and constellations."

6. "Topics based upon physics and chemistry are related largely to the home or agriculture. Simple physics of the soil appears in all but two of the state courses. Other topics are: Vaporization and condensation, heat, light, air, electricity, machinery, sound, combustion, elements and compounds, acids, salts, and alkalies."

7. "The city courses show about the same per cent of biological material as those of the state. A few of them, however, in the upper grades give considerable attention to experiments in pure physics and chemistry."

8. The state courses with but few exceptions, group the matter all under two headings: Nature study for the six lower grades, and agriculture in the seventh and eighth grades.

9. "Observation and handling of material are emphasized throughout the courses." The encouragement of the children in the observing of objects at home and on the way to school, and in the bringing in of interesting objects, is suggested in more than 90 per cent of the courses, as is also the field excursion.

10. "Muscular activities of children as related to the nature study are given prominent recognition. The care of pets is suggested in 60 per cent of the courses. Fish and

larvae of water insects in aquaria, insects in terraria, pet toads, cats and dogs, canaries, and pigeons, are all named as interesting pets to have in the school-rooms for the lower grades."

11. "Seventy-five per cent of the outlines suggest the making of collections of various kinds. Some of the most common are seed charts, leaf charts, pictures of farm animals, collection of nuts, pebbles, weed seeds, grains of the community, and seeds of flowering plants and vegetables."

12. "Forty per cent advocate the training of the creative powers of children in the making of articles in connection with their nature study, such as a doll house in the lower grades, a farm house or barn in the intermediate grades, scrap books, foods such as candy, butter, cheese, maple sugar, and simple pieces of apparatus, as electric door bells and pumps."

13. "Over 90 per cent suggest garden work with a number of allied activities, as the germination of seeds, making cuttings, budding, spraying, corn gathering and judging, and planning and arranging a garden display."

14. Eighty-five per cent of the courses studied suggest a correlation of nature study and elementary agriculture with language. Sixty per cent suggest that the drawing be correlated with the nature objects under consideration in the nature classes. About 25 per cent suggest some correlation with geography, and about the same percentage suggest some correlation with human physiology, hygiene, and sanitation. "Domestic science and manual training are suggested as worthy of correlation in a few of the courses," and "about the same number show that arithmetic and reading may be in part consistently correlated with nature study topics."

STUDY NO. 6C

Range of Information Test in Biology. I. Physiology

By N. M. Grier*

Problem.—To determine (1) whether physiological knowledge acquired in the grades may be disjointed and fragmentary, and (2) whether physiology may hold a justifiable place in the high school program of studies, considering the fact that barring anatomical detail and technical terminology, grade-school pupils, when entering high school may already possess a *reasonable* amount of information regarding the human body.

Method.—One hundred test words were selected thus: A list was first prepared of all those words pertaining more directly to physiology found in the spellers and readers previously used by pupils in their grade-school work; a similar list was taken from articles dealing with pure food and health found in the daily newspapers and more widely known monthly magazines. From these lists, 100 of the more frequently recurring words were checked in the glossary of the text-book as being (1) words in fairly common use, which it was thought cultural values to be derived from science demanded that pupils should know; (2) words, a knowledge of which would indicate some familiarity with the care of the body and the activities of its organs. ". . . an effort was made to distribute words evenly among the divisions of the subject."

These words, printed on a test-blank, were given to 40 first-term pupils who were taking up botany at the time, and to 97 second-term pupils who were beginning physiology

* *The Journal of Educational Psychology*, April, 1918. Vol. IX, pp. 210–216.

after having completed botany. The pupil was asked to place D before the terms he could define as exactly as words are ordinarily defined in the dictionary; E before terms he could explain to one not familiar with their meanings; F before terms with which he was roughly familiar; and N before terms new to him. He was told to write at the bottom of the sheet the definitions of the first five marked D and the first five marked E, to count the number of D's, E's, F's, and N's, and to record the results at the top of the page. The pupil was asked to read the directions through twice before marking the words, and was allowed all the time he needed for the test.

As a check on the marking of the pupils, the 100 words were defined by the examiner from the glossary of the grade-school text-book while each pupil placed a second mark after each word to indicate the manner in which he should have marked it. A comparison of the number of D's, E's, F's, and N's of the first and second markings showed with a fair degree of accuracy "the extent and nature of the error due to ignorance or misunderstanding of the real meanings. The results were classified as to the dependence of the range of information of physiology on (1) Academic status; (2) Sex; and (3) Academic status and sex."

The results obtained from the pupils were checked against those secured by administering the list as a *trial test* to 12 young men of average age 20, most of whom had never attended school.

Findings.—(1) A comparison of the results secured from the first and the second-term pupils indicated that "with increase of maturity occurs also an increase in the number of technical terms which can be explained (E), or that are at least familiar (F), [but] a decrease in the number which can be defined (D)." The experimenter suggests as a reason

for this last fact that the comparatively long time, a term and a summer vacation, elapsing before high school physiology was taken up had somewhat altered the conceptions of the pupils.

"The increase of E's was probably because certain of the test words are used in the preceding course, botany. Another factor possibly affecting the results is the knowledge obtained through the wide-spread propaganda against disease and for better living inaugurated by various civic organizations and the articles in newspapers and magazines forming a partial basis for this test."

2. That "knowledge of the body . . . increases with age" was indicated by the fact that very high percentages of E's and F's, and practically negligible percentages of D's and N's were obtained from the trial test. The advantages of the high school course in physiology may be doubted under these conditions; this conclusion is supported by the fact that in the second marks (indicating how the pupil should have marked the words) the number of words defined (D), explained (E), and familiar (F) was decidedly greater than the number of words which were new.

3. The average error of marking (the difference between the first and second markings) with the first-term pupils was 72 per cent, while that of the second-term pupils was 64 per cent—a fact "showing that there also occurs with maturity some advance in discriminative power."

4. "The results . . . show a general superiority in boys in range of information of physiology. This is in accord with the results obtained by Whipple and Smith . . ."

5. The evidence of clearer concepts in boys than girls is shown in the fact that the sum of the N's found in the second marks is less and that there is a greater percentage of D's

and E's among the boys. "The average error with the boys was 56 per cent; with the girls, 8 per cent."

STUDY NO. 7C

Range of Information Test in Biology. II. Zoology

By N. M. Grier,*

Problem.—To determine (1) whether zoological knowledge acquired in the grades may be disjoined and fragmentary, and (2) to what extent "natural history" shall form part of the course in zoology, by an investigation of the knowledge which pupils entering the high school from the grades possess of those main forms of animal life entering into direct economic relation with man; and (3) whether the study of physiology and physiological principles shall form part of the course in high school zoology, considering the fact that an essential feature of biological thought is that the activities of the human body be interpreted from the comparative standpoint.

Method.—One hundred test words were selected thus: A list was first prepared of all those words pertaining directly to botany and zoology discovered in the spellers and readers previously used by the pupils in their grade school work; a similar list was made from the Boy Scouts' and Camp-fire Girls' publications. From these lists and one prepared by Mr. Dougan, who recently had charge of the revision of nature study courses in St. Louis schools, 100 of the more frequently recurring words were checked. In selecting words the experimenter, like Mr. Dougan, chose (1) "words in fairly common use, a knowledge of which would indicate

* *The Journal of Educational Psychology*, September, 1918. Vol. IX, pp. 388–392.

the range of information" regarding the "natural history of animals [which are] of outstanding interest to man"; (2) "words, a knowledge of which would [not only] indicate some familiarity with physiological processes," but "would be representative of lower animal groups as well as of man."

The test was given to 26 first-term pupils, taking up the study of botany at the time, and to 87 second-term pupils who had finished botany and were beginning the study of physiology. The method of giving, scoring, and checking the test was the same as in the investigator's previous study[1] except in presenting the test the pupils were told how the terms were selected and that the terms pertained directly or indirectly to animals.

Findings.—(1) With maturity there is some increase in the number of terms that can be defined (D), and explained (E), and that are familiar (F), and a corresponding decrease in the number of terms new to the pupil (N), but as in the preceding investigation,[1] the greatest change is in the number of F's. The difference between the number of D's and E's in the first marking and in the second (indicating how the pupil should have marked the words) is so slight and decreases to such an extent in the second marking that, so far as a knowledge of natural history is concerned, the experimenter is "inclined to attribute the increase to more highly organized motor processes of the second-term pupils, as shown by their ability to carry out more readily the experimenter's instructions" while taking the test. "This [opinion] is somewhat substantiated by the fact that three of the test words used occur in the preceding course of botany."

2. "The checking up process increases the number of D's and E's and decreases the number of F's and N's."

[1] Study No. 6C.

3. Some confirmation of Lloyd and Bigelow's statement that pupils' interest in natural history declines at this age, is shown by the want of a more decided increase in the number of D's and E's, and also by the average error of marking (6 per cent with the first-term pupils, and 8 per cent with the second-term pupils). If the pupils' interests were more active, a greater percentage of D's and E's could be expected in second-term pupils who might be expected also to show a smaller percentage of error. "At best, it seems that discriminatory power in the subject of natural history has not advanced."

4. The results, reclassified by sex, show no significant differences between the sexes except in the percentage of error after the second marking. These markings indicate that the boys are more accurate than the girls in judging the exactness of their comprehension of the 100 terms.

STUDY NO. 8C

Range of Information in Biology. III. Botany

By N. M. Grier*

Problem.—To determine (1) whether botanical knowledge acquired in the grades may be disjointed and fragmentary, and (2) whether nature study contributes a foundation for high school botany.

Method.—A list of 100 more frequently occurring words pertaining to botany was secured as in the two preceding investigations[1] from spellers and readers and Boy Scouts' and Camp-fire Girls' publications. The words chosen were (1) words in fairly common use, a knowledge of which would indicate the range of information concerning those phases

* *The Journal of Educational Psychology*, December, 1919. Vol. X, pp. 509–515.

[1] Studies No. 6C and No. 7C.

of plant life about which the pupils might be expected to know from nature study, school gardens, etc.; and (2) "words, a knowledge of which would indicate some familiarity with biological principles and [with] the relation of plants to the lower animal groups as well as to man." The method of administration, marking, and checking the test was the same as in the preceding studies[1] except that the pupils were told how the terms were selected and that they pertained directly or indirectly to plants.

The test was given to 97 first-term pupils who were just taking up the study of botany at the time, and 86 second term pupils who were beginning physiology after having finished botany.

Findings.—(1) The results show that with maturity there is a decided increase in the number of terms which can be defined (D), explained (E), and a corresponding decrease in the number of terms new to the pupil (N).

2. From the results of this investigation it may be inferred that the completion of a regular, organized study of a subject gives the pupil an ability to define or explain more words pertaining to it, while the pupil pursuing the subject casually or without constant supervision finds more words which are merely familiar or even new to him. "In the first type of study, the ability to define exceeds the ability to explain . . . while in the second type of course these abilities are practically equal."

3. ". . . to the pupil untrained in botany, 20 per cent of the representative terms are generally familiar, while the pupil trained in botany may explain rather than merely know 31 per cent of them."

4. That discriminating power increases with maturity and training was shown by the percentage of error between

[1] Studies No. 6C and No. 7C.

the first and second markings: 4.7 per cent with the first-term pupils and 3.8 per cent with the second-term pupils.

This fact is explained as being due to the advantages of the second-term pupils with respect to more constant supervision of the organized class-room work, especially trained teachers, etc.

5. The D's were more numerous and the N's fewer in botany than in either of the preceding tests on physiology and zoology, possibly because illustrative material is more abundant in botany. This fact may account for the lowest percentage of error in it of all three subjects and may be taken as indicative that ". . . high school botany as a subject has the best basis of all the biological subjects upon which to build, and probably more elementary botany could safely be included in the course of nature study. With such an aid to effective teaching, there would seem to be no excuse for its failure to persist in the curriculum."

6. "Reclassified by sex, the results show a slight superiority of the girls in range of information in nature study. This somewhat substantiates the old tradition of botany being a 'girls' subject.'"

7. As was also shown in the investigation of zoology, "these particular concepts are clearer with boys than with girls, regardless of what the boys may retain. This [inference] checks with the percentage of error, 2 per cent with boys and 7 per cent with girls."

8. It was previously found that the boys showed a greater range of physiological information than the girls but girls excelled in knowledge of nature study, as shown by this study and the investigation with zoology. The percentage of error is practically the same in this as in the latter paper, 2 per cent with the boys and 6 per cent with the girls.

9. The results of these three investigations seem to indicate that physiology is a more difficult subject than zoology and botany.

10. "The results differ from those secured in zoology in that the second-term boys know more than the girls and in addition have clearer ideas."

STUDY NO. 9C

Fundamentals of Subject Matter

By R. W. Osborne* (Chairman)

UNIT I

Problem.—To redefine the purposes and aims of chemistry teaching, and to formulate the objectives which we want classes to reach as a result of their study.

Method.—The committee arranged the aims in psychological order, that is, the order in which the pupils should become conscious of them. These aims were embodied in the first section of a questionary which was submitted for criticism to teachers of chemistry. The aims follow:

A. To supply a "motive to the pupil through his conception of the value of the work to himself and the opportunities for achievement which it offers."

B. To insure to the pupil the understanding of the scientific method of procedure, and the ability to use it as a means of solving his problems.

C. To insure the "acquisition of knowledge as a basis of skill."

D. To give an "appreciation [of life] which means the comprehension and understanding of the phenomena of life."

* Report of the Committee on Reorganization of High School Chemistry, Minutes of the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 28, 1919. *School Science and Mathematics*, March, 1920. Vol. XX, pp. 240–242.

E. To give an appreciation of "ethical and moral values through conceptions of the universe as governed by law unchanging and ever-operative."

Findings.—(1) "Forty-two replies to this statement of aims showed 37 in entire agreement and 5 with only slight modifications."

UNIT II

Problem.—To formulate (in accordance with the aims and objectives stated in Unit I) the content of the course in chemistry in terms of concepts rather than materials.

Method.—On the second section of the questionary, concepts were listed in such a way that the teacher might indicate whether a given concept was considered fundamental, whether it was taught but not stressed, or whether omitted from the course.

Findings.—(1) "With only a few exceptions the groups, laws, theories, laboratory technique, topics, and types of chemical change show a very high degree of agreement. This indicates that chemistry teachers are in harmony as to these fundamentals."

TABLE I

CHEMICAL CONCEPTS CONSIDERED FUNDAMENTAL, TAUGHT BUT NOT STRESSED, AND OMITTED IN COURSES TAUGHT BY FORTY-TWO TEACHERS REPLYING TO QUESTIONARY (OSBORNE REPORT)

Concepts	Considered fundamental	Not stressed	Omitted
I. Laws			
1. Dalton	40	2	0
2. Avogadro	39	2	1
3. Charles	39	3	0
4. Boyle	39	3	0
5. Gay-Lussac	39	2	1
6. Periodic	31	10	1
7. Berthollet	28	8	6
8. Mass action	26	11	5
9. Raoult	23	13	6
10. Henry	20	16	6
11. Faraday	19	12	11
12. Dulong and Petit	16	9	17
13. Vant Hoff	10	16	16
II. Theories			
1. Molecular	42	0	0
2. Atomic	42	0	0
3. Ionic	40	1	1
III. Simple Laboratory Technique			
1. Manipulation	39	3	0
2. Tests for ions	37	5	0
3. Titration	32	9	1
4. Cleanliness and order (added)	1		
IV. Topics			
1. Elements, compounds, and mixtures	41	1	0
2. Metric system	41	1	0
3. Matter and energy	41	1	0
4. Solution	40	1	1
5. Anhydrids	40	2	0
6. Valence	39	3	0
7. Nitrogen and carbon cycles	38	3	1
8. Carbon compounds	34	8	0
9. Hydrates	32	10	0
10. Allotropy	30	12	0
11. Osmosis	26	7	9
12. Colloids	24	10	8
13. Isomerism	22	14	6
14. Crystalloids	21	12	9
15. Radio-activity	20	16	6
16. Critical temperature and pressure	17	12	13
V. Types of Chemical Change			
1. Oxidation and reduction	41	1	0
2. Hydrolysis	41	0	1
3. Metathesis	40	2	0
4. Catalysis	40	2	0
5. Electrolysis	38	4	0
6. Equilibrium	37	5	0
7. Fermentation	36	6	0
8. Activity series	33	8	1
9. Photosynthesis	33	9	0
10. Common metals and groups (added)	1	..	..
11. Exothermic and endothermic changes (added)	1	..	..

TABLE I (*Continued*)

Concept	Emphasized[1]
VI. Applications in Home and industry	
1. Sanitation and health	26
2. Foods and nutrition	25
3. Metallurgy	25
4. Water purification	24
5. Fuels	22
6. Cement	22
7. Lime	22
8. Antiseptics	22
9. Disinfectants	22
10. Glass	21
11. Sulphuric acid	21
12. Pottery	20
13. Bleaching	20
14. Adulterants	20
15. Preservatives	20
16. Photography	19
17. Drugs	19
18. Poisons	19
19. Antidotes	18
20. Dyeing	18
21. Explosives	18
22. Fertilizers	18
23. Matches	18
24. Electroplating	17
25. Textiles	17
26. Paper	17
27. Refrigeration	17
28. Illuminants	17
29. Paint	17
30. Laundering	17
31. Abrasives	15
32. Insecticides	15
33. Fungicides	15
34. Inks	11
35. Cosmetics	7
36. Alloys (added)	1
37. Oils, resins, and gums (added)	1
38. Leavening agents (added)	1
39. Sugar (added)	1
40. Coal tar (added)	1
41. Rubber (added)	1
42. Leather (added)	1

[1] Scoring under VI indicates that the item is merely emphasized. No great agreement is desired or expected, because of the varying local conditions and of the individual differences of the pupils.

STUDY NO. 10C

A Test of High-school Chemistry

By Henry Lester Gerry*

Problem.—To analyze the College Entrance Examinations Board questions in chemistry, in order to determine if possible the portions of elementary chemistry which the examiners seem to have considered most important, or, at least have asked most frequently.

Method.—The investigator analyzed the "Definition of the Requirements in Chemistry,"[1] and also analyzed into nearly 900 items, 10 sets of the Old Plan Examinations, the June Comprehensive Examinations for 1916 and 1920, and the June and September Comprehensive Examinations for 1917, 1918, and 1919—18 sets of examination papers in all. ". . . since not all questions on College Board Examinations [however] have the same grading value, since [moreover] the questions were dissected and part-questions entered in the material from which generalizations have been drawn, and since these part-questions often were entered more than once, the number of items under any one topic does not give the relative value in the minds of the examiners of that phase of the subject, but rather furnishes a rough measure of the frequency of recurrence of that topic."

* Doctor's thesis. Harvard Bulletins in Education, No. IX. Cambridge, Massachusetts: Harvard University, September, 1924.

The curricular phases of this study are here taken from the investigator's supplementary article, "College Entrance Examination Board Questions in Chemistry." *School Science and Mathematics*, December, 1920. Vol. XX, pp. 845–850.

[1] College Entrance Examinations Board Document No. 93.

Findings.—(1) There was found to be an almost annual occurrence of a series of partial equations, and a "frequent occurrence of the equations representing a reaction in which barium sulphate is formed, copper reacts with nitric acid, hot concentrated sulphuric acid and copper interact, and in which the products of heating concentrated nitric acid are indicated."

2. Every examination paper analyzed had at least one problem involving chemical arithmetic—most frequently a problem concerning the volume of a gas derived from a known weight of one of the reacting substances. In each of the Old Plan Examinations since 1910 there was found an average of nearly five questions, or parts of questions, which required an arithmetical solution; in each of eight Comprehensive Examinations since 1915, was found an average of about four stoichiometrical problems.

3. The Electrolytic Dissociation Theory was found to be included in some manner in all, or practically all, the examination papers. A question might require the explanation of a simple case of electrolysis; it might involve neutralization, the reaction to litmus of a dilute solution of copper sulphate or sodium carbonate, the use of electricity in electroplating or any two or more of these phases of the topic. "Some one of the other theories or some common law of chemistry is scarcely ever omitted from a question paper."

4. "Knowledge of the laws of Boyle and Charles until recently has been tested by numerical problems. The June, 1920, Comprehensive Examination, however, had a question designed to determine the understanding of the relationships between volume, temperature, and pressure of a gas without asking for a statement of the laws or for a solution of a problem."

Table II

Per Cent of Frequency of Most Common Types of Questions and Topics in College Entrance Examinations Board Questions in Chemistry, 1911–1920 (Gerry Study)

Items	Per Cent of Frequency
I. Numerical Problems	
1. Law of Boyle	7.9
2. Law of Charles	10.5
3. Definite proportions	1.3
4. Multiple proportions	3.9
5. Percentage composition	21.2
6. Weights of substances concerned	19.7
7. Volume of a gas resulting from a reaction	35.5
II. Chemical Theory	
1. Law of Boyle	6.3
2. Law of Charles	8.1
3. Law of conservation of mass	2.7
4. Law of conservation of energy	1.8
5. Law of definite proportions	5.4
6. Law of multiple proportions	4.5
7. Law of Gay-Lussac	3.6
8. Atomic theory	8.2
9. Avogadro's hypothesis	1.8
10. Electrolytic dissociation theory	32.4
11. Valence (aside from equations)	3.6
12. Energy changes	5.4
13. Oxidation and reduction	12.6
14. Catalysis	3.6
III. All Topics	
1. Common non-metallic elements	8.4
2. Common metallic elements	3.6
3. Common acids	8.7
4. Salts, oxides, and hydroxides	13.8
5. Gases (not elements)	6.9
6. Organic substances	2.5
7. Identification (laboratory)	10.0
8. Quantitative experiments	0.6

TABLE II (*Continued*)

ITEMS	PER CENT OF FREQUENCY
9. Equations	14.5
10. Reversible reactions	1.4
11. Laws and theories	5.9
12. Electrolytic dissociation theory	3.9
13. Chemical arithmetic	
(a) Percentage composition	1.8
(b) Weights of substances concerned	1.7
(c) Volumes of gas from a reaction	3.1
14. Energy changes	0.7
15. Oxidation and reduction	1.7
16. Solutions	2.1
17. Others	8.7

5. "It is unusual to find a question paper that does not in some way draw upon the laboratory experience of the pupil for the material of the answer. Questions of this nature have been those asking for the description of a piece of laboratory procedure, for the identification of specified substances, for the separation of two somewhat similar materials, or for means of distinguishing pairs of elements or compounds. This type of question has made up 11.6 per cent of the items of the Ordinary Examinations and 7.6 per cent of the Comprehensive."

6. "In the Old Plan Examination papers, questions requiring information about the common non-metallic elements have occurred nearly twice as frequently as those on the common metallic elements, and less than half as many times as those on metallic salts, oxides, and hydroxides. Questions on non-elementary gases and on common acids each have occurred in the same series of papers nearly as frequently as those on the non-metallic elements. These five groups of questions have comprised quite 45 per cent of the items in the 10 Old Plan Examinations since 1910."

In the Comprehensive Examinations, questions on the common metals are least frequently asked; questions on non-elementary gases occur more than twice as frequently; and questions on common non-metallic elements, on common acids, and on salts, oxides, and hydroxides occur from three to four times as frequently.

STUDY NO 11C

Scientific Method in the Construction of School Text-books,*

By Carleton W. Washburne,*

Problem.—As a means of determining what subject matter should be included in a text-book of general science, (1) to collect the scientific questions of children, (2) to ascertain scientifically explainable facts "common in the experience of most people," and (3) to determine "what applications of science are commonly made in everyday life."

Method.—In collecting the scientific questions of children, the investigator went into class-rooms ranging from the fifth to the eighth grades, and invited the children to ask any questions they might care to; he then answered these questions briefly but definitely. The variety of topics asked about increased as the number of question hours increased and the children learned to save up their questions for the next question hour.

After several months the investigator had a number of his advanced students in the teaching of science reserve one period each in which the children might ask questions to be answered by their teacher of science during the next class period. Altogether, over the period of a year, about

* From Washburn, *Scientific Method in the Construction of School Textbooks*. World Book Company, Publishers, Yonkers-on-Hudson, New York.

2000 questions were collected from pupils in the elementary department of the San Franciso State Normal School and from pupils of the San Francisco public schools. Questions of a purely local nature and those not scientific were discarded.

To secure a list of scientifically explainable facts commonly experienced, the investigator organized a contest among the students of the San Franciso State Normal School preparing to teach science. They were told to "jot down on separate slips of paper every day, facts or experiences that could be explained in terms of any scientific principles. Typical examples were, "Raindrops stick to the window pane." "Smoke from a cigar usually rises." About 50 students participated in the contest; the winner of the prize contributed over three hundred.

The third source of data consisted of a collection of experiences involving practical applications of science in the daily lives of friends, fellow faculty members, and students. These involved many of the facts already collected, but provided an additional source of material.

"The entire mass of data collected from all three sources was placed upon small slips and then classified according to the scientific principles needed in order to answer the question or to explain the fact or to make the practical application." "Where there were two or more children's questions, a number of commonly experienced facts, and some practical applications [all involving the same scientific principle] the principle was included" in the outline of general science.

Findings.

CURRICULAR ELEMENTS OF GENERAL SCIENCE (WASHBURNE STUDY)

1. Gravitation: "Where things weigh nothing"; "where there is no up and down"; "water seeks its own level"; air pressure; displacement; stability

2. Molecular attraction: Capillarity; adhesion; cohesion; friction

3. Conservation of energy: Levers; inertia; centrifugal force; action and reaction; elasticity

4. Heat: Expansion from heating; cooling from expansion; freezing and melting; evaporation; boiling and condensing; conduction and convection

5. Radiant heat and light: Radiation from the sun; incandescence; reflection; refraction; focus; magnification; diffusion of light; color

6. Sound: Nature; echoes; pitch

7. Magnetism and electricity: Magnets; compass; static electricity

8. Electricity: Making electricity flow; conduction; complete circuits; grounded circuits; resistance; electric arc; short circuits and fuses; electromagnets

9. Mingling of molecules: Solutions and emulsions; crystals; diffusion; humidity; softening due to oil or water

10. Chemical change and energy: Elements; oxidation; chemical changes caused by heat, light, and electricity; "chemical change releases energy"; explosions

11. Solution and chemical action: Chemical change helped by solution; acids; bases; neutralization; effervescence

STUDY NO 12C

Some Studies of Children's Interests in Science Materials

Charles W. Finley,*

UNIT I

Problem.—To secure data on children's interest in animals.

Method.—The subjects of this investigation were 1716 children in grades one to eight in 13 schools presenting a wide range in type.

* Master's thesis. The following digest of this study is made from a report under the same title in *School Science and Mathematics*, January, 1921. Vol. XXI, pp. 1–24. A brief summary is found in the *Third Yearbook*, Department of Superintendence, N. E. A., 1925. p. 301.

A live "water-dog" or "mud-puppy" in a glass aquarium was taken into the class-room. In grades three to eight the children in small groups viewed the animal for a three minute period, during which no oral questions or discussion were permitted; they then returned to their seats and, in writing asked about the animal all the questions they desired to have answered. In the first and second grades the teachers and the experimenter wrote down the questions all of which the children whispered to them. After the questions had all been secured, the investigator gave a short talk concerning the animal, taking care that no phases of interest revealed by the questions were overlooked.

The questions were classified under the following phases of interest in the animal: Identification, Classification, Environment, Food, Life History, Adaptations, Movements, Geographical Distribution, Use, Habits, Structure, Gills, Function of Parts, Enemies, Abundance, Sex Color, Evolution, Dangerousness, and Teleological questions.

As a check on this experiment, 40 days after they had had the discussion on the mud-puppy, the children in the fourth, fifth, sixth, seventh, and eighth grades in the University of Chicago Elementary School were requested to write a composition on the animal. During this 40-day interval no further work had been given on the animal, and neither pupils nor teachers knew that the written work was to be called for. As in the first experiment no questions or suggestions were permitted and no words were spelled for the pupils.

Findings.—(1) A tabulation of the phases of interest revealed in the compositions shows close agreement with the tabulation of phases of interest shown by the questions. ". . . the check thus supports the contention that in this

experiment the children's questions are indicative of their interests."

2. By far the greatest number of children asked the name of the animal. On most of the papers this type of question (identification) was the first asked.

3. Little interest in classification was shown below the fourth grade and only a slight interest above.

4. The numbers of questions asked regarding the animal's environment amounted to less than $\frac{1}{5}$ of the number of children in grades one and two, to $\frac{3}{4}$ of the number of pupils in grade three, and in all the other grades to a still larger portion.

5. In the lower grades little interest was manifested in the kind of food eaten by the animal; in the upper grades, however, much interest was shown in this phase, though with little variation in grades four to eight.

6. Interest in the life history of the animal increased in the upper grades.

7. The interest in adaptations to environment increased in the successive grades.

8. Not many questions pertaining to the movements of the animal were asked except in the rural schools and one city school. Grades four and five showed most interest in this phase.

9. There were practically no questions on geographical distribution or which definitely indicated an economic interest in the animal below the fifth grade, but from the fifth grade to the eighth there was manifested an increasing interest in these phases.

10. The interest in the habits of the animal was not great and showed little variation throughout the grades.

11. Considerable interest in structure was manifested in all grades, but most interest in the fourth, fifth, and sixth.

12. The children below the fifth grade did not seem to recognize the gills as extraordinary.

13. "A perusal of the graph[1] seems to show that fear of animals is a thing taught the pupils as it is more manifest in the successive grades." The contention that the first reaction of a city boy to an unknown animal is to find out whether the animal is dangerous and immediately to lay plans to get rid of it, is not here substantiated.

14. There was manifested in the upper grades a very definite falling off of interest in teleological questions (as, "Why has he such a flat head?" "Why is his tail so long?" etc.). Such questions were supplanted by those seeking "reasons" for structural characteristics.

15. While the graphs[1] pertaining to environment, food, life history, adaptations, classification, geographical distribution, and use agree in showing a designated increase in interest in the successive grades, there is a lowering of the graphs in the order mentioned above; "the curves of distribution are high in the 'Environment' graph and very low in the 'Use' graph."

16. "Questions pertaining to function of parts, enemies, abundance, sex color, and evolution were few and the distributions of them failed to show differentiation from which scientific conclusions might be drawn."

UNIT II

Problem.—To secure data relating to children's interests in three phases of elementary science, plants, animals, and physical phenomena.

Method.—This investigation involved 827 children in grades three to eight in five schools, three of which were represented in Unit I.

[1] The investigator's graphs are not here reproduced.

Care was taken to give an equal amount of stress to the presentation to each class of a topic of plant life (the life-plant), one of animal life (the black-skimmer), and one in elementary physics (the pendulum). The plant, the bird, and the pendulum were presented to the classes in varying orders and were each explained and discussed with free class participation for a period of from 8 to 10 minutes. At the close of the exercise, the regular teacher was given a typewritten set of instructions concerning the further procedure, according to which she was requested to call for a written exercise the following day, permitting each pupil to write on one only of the three objects. The topic upon which each pupil wrote was taken to indicate which of these three objects presented was most interesting to that pupil.

As an additional check upon the children's interests, just two weeks after the exercises had been given, the children in one school were asked to indicate on slips of paper which of the objects previously demonstrated they would choose to consider, if they might have another discussion of one of the three.

Findings.—(1) In 22 of the 25 classes the bird was the topic about which most compositions were written by the pupils. More than half of the choices expressed in the check experiment, moreover, were for the bird.

2. Inasmuch as the bird received most consideration in each grade, the order in which the objects were presented to the classes showed no effect on the pupils' response.

3. In 7 of 9 classes in which the boys' and girls' response were tabulated separately, the boys and girls agreed in writing most of their compositions upon the same topic.

STUDY NO. 13C

Report of the Sub-committee of the Central Association of Science and Mathematics Teachers (1920) on the Content of High School Physics

By C. L. Vestal,* (Chairman)

Problem.—To prepare an outline or syllabus for a course in physics for the high school from the point of view of life situations.

Method.—Unstated.

Findings.—The complete outline follows:

LABORATORY METHODS (POSITIVE)

What to aim at:

A. Verisimilitude—natural association in pupils' minds of the apparatus and operation with real things.

B. Intermixing of laboratory work with recitation and discussion.

C. Simplicity and *directness*—get results without roundabout methods.

D. Deduction of laws, as far as possible, from observed facts.

E. Group methods of work.

F. Some immediate utilitarian value now and then—household consultation.

LABORATORY METHODS (NEGATIVE)

What not to aim at:

A. Determination of physical constants—not a course in measurements.

B. Proof (quantitative) of laws in all cases.

C. Sharp differentiation between laboratory and class work.

D. Manipulation of experiment by each pupil.

* *School Science and Mathematics*, March, 1921. Vol. XXI, pp. 274–279.

E. Rigid and formal methods of demonstration.
F. Grasp of abstractions.
G. Too much reliance on lecture table demonstrations.
H. Too severe adherence to the topic under discussion.

PHYSICS OUTLINE OR SYLLABUS FROM THE POINT OF VIEW OF LIFE SITUATIONS (VESTAL REPORT)

I. Mechanics of Solids.

1. Levers: Scissors; crowbar; jack handles; human arm; balances; teeter-board; wheelbarrow; hoe and rake; claw-hammer.
2. Wheel and axle: Bicycle; auger; brace and bit; grindstone; sewing-machine drive; crank and wheel of steam engine; food grinder; clothes-wringer; automobile final drive; double gears; crank-shaft and flywheel of automobile engine.
3. Pulleys: Hoists of all kinds, as those used by painters of buildings; derricks; devices for hoisting hay into barns and for stacking hay; freight handlers' differential pulley.
4. Inclined plane: Loading slopes or skids; screws.
5. Gears: Automobile gear shift; differential gear; clock gears; gears in electric meter, gas-meter, water meter; worm gear, as in some auto trucks.
6. Work and power taught by these machines: Measurement of power by brake method, with small electric motor, or of hand power by turning crank, as with a bicycle. Efficiency.
7. Force and motion: Typical and common cases of components and resultants, as, for the former, the incline—a load on a hill, road and railway grades—the pendulum, the lawn-mower, the sail-boat, the kite, or the wings of an aeroplane; sliding down hill—tobogganing, ski-jumping, chute-the-chutes, scenic railway at amusement parks; acceleration of an auto or a train; retardation of moving vehicles—braking power. Inertia: Effects of sudden starting and stopping; momentum, as shown in colliding things, as when switching locomotive bumps cars; centrifugal force, illustrated by race-tracks, baseball diamonds, railway curves, slings, merry-go-rounds, giant swings at amusement parks, cream separators, clothes-dryers; centrifugal governor—as on steam engine or in talking machines, sparks from wheel, water from grindstone or mud from vehicle wheel, bursting flywheels or emery wheels.

8. Reactions: Recoil of gun; rotary lawn-sprinkler—demonstrating that force is always in both directions. Gravity and center of gravity: Stability, as in moving vehicles—for example, limit of height of locomotive; ships' ballast, counterbalancing rotating weights—as steam engine flywheel, locomotive drive wheels, or automobile crank shaft, feats of balancing by tight-wire performers and vaudeville performers.
9. Elasticity and Hooke's law: Vehicle springs; spring balances; beams for buildings, bridges, etc.; strength of material and methods of testing same; rebound of balls, as in billiards, pool, tennis, golf, baseball, football, basketball, soccerball.

II. Mechanics of Liquids.

1. Flotation: Boats and ships; buoyancy on things heavier than water as the submarine and diver; hydrometers, as used for testing acid in storage batteries, or for testing milk and other liquids.
2. Water Supply and Distribution: Pressure by standpipes or elevated tanks; drop in pressure in a water-carrying pipe, as shown when many people use their lawn-hose at the same time; house-piping, faucets, and valves; metering; plumbing devices; drainage and sewage disposal.
3. Pumps and Pressure Devices: The ordinary lift pump; pumps, as used in pumping stations; the fire-engine pump; the hydraulic ram; centrifugal pumps. Pascal's law: the hydraulic elevator; barbers' chairs; dentists' chairs; the hydraulic press.
4. Water Power: Potential and kinetic energy of rapids and water-falls, waterwheels and turbines, and little water motors.

III. Mechanics of Gases.

1. Air Pressure: The atmosphere; lung action; pneumatic tires; pumps; bellows; air-filled balls,—basketball, tennis ball, and football; the barometer; pressure and altitude—effects of mountain climbing, of going to the top of a tall building in an express elevator, and of reaching great heights in an aeroplane. Boyle's law: Compression in the tire pump, and in the gas engine cylinder. The wind: Wind turbines or "windmills." Distribution of illuminating gas—pressure and pressure loss. Distribution of water by air-pressure tank; air cushions on water system; the air chamber on force pump.

IV. Molecular Forces.

1. Adhesion: Most liquids wet solid surfaces.
2. Cohesion: Formation of drops; viscosity, surface tension, as shown by floating needle, by insects walking on water, and by bubbles.
3. Capillary action: Blotters; towels; soil taking water; wicks.
4. Solution of gases in liquids—carbonated water, ammonia, hydrochloric acid.
5. Kinetic theory of gases: Accounting for gas pressure by molecular bombardment; temperature and molecular velocity; different rates of diffusion of different gases, as air and illuminating gas.
6. Kinetic theory of liquids: Evaporation; rates of evaporation of different liquids—volatility; importance of volatility, as in gas engine fuel; volatility and temperature; the drying of clothes and of the soil.

V. Heat.

1. Expansion and contraction: Thermometers—liquid and metallic thermometer scales, F. and C.; allowance for expansion in construction work,—rails, steel beams, sidewalks, timepieces; thermostatic control; expansion of air, causing air currents and winds; rise in pressure by heat, as air in heated automobile tire, expansion currents in heating a house —convection; expansion of liquids in heating by convection; review of molecular theory of expansion and pressure.
2. Specific heat: Different materials, as iron, aluminum, copper, etc., hold different quantities of heat. Unit quantity of heat, the calorie and the B. T. U.
3. Heating and ventilation: Meaning of ventilation; house heating plants,—hot air, hot water, steam; discussion of theory and relative merits of each; care of each kind of plant, management of fuel and ashes; relative merits of fuels—ease of combustion and heat content; radiators and "radiation"; relation between room size and radiator surface; "conductors" of heat; direct and indirect systems of steam heat; heating public buildings.
4. Refrigeration: "Heat of fusion"; heat taken up by melting ice; heat of compression; artificial ice and ammonia refrigeration; making liquid air or other liquid gas.

5. Power from heat: "Mechanical equivalent of heat"; "heat of vaporization"; steam engine; gas engine; hot air engine; steam turbine. Efficiency of these machines. Factors governing efficiency. Study of the automobile engine as to construction and method of operation—carburation, heating of fuel, proper combustion; carbonization and remedies therefor; effect of engine speed on fuel mixture; effect of altitude on fuel mixture.
6. Friction: Cause of friction; bearings—plain, roller, ball, with advantages and disadvantages of each; lubrication—proper weight and viscosity under different conditions; gas and steam engine lubrication; so-called "coefficient of friction."
7. Radiant heat: Colors of clothing with reference to heat—selective absorption and radiation.
8. Heat insulation: Covering with felt or magnesia, steampipes, hot air pipes, and hot water pipes; boiler coverings; insulating properties of different types of house walls; refrigerator walls; fireless cookers.
9. Importance of heat conservation: Sources of fuels; their limited supply; best forms for use; development of water power; conservation of energy; perpetual motion; transformation of energy.

VI. Electricity and Magnetism.

1. Static charges: Charge on rubber combs, fountain-pen handles running belts, from moving feet on rugs, from fur, flannel, silk, sealing wax, fiber, glass, etc.; positive and negative charges—the electron theory; electric potential; electric capacity; electro-static induction; insulators and conductors; condensers; atmospheric electricity—lightning, the lightning rod.
2. An electric current: A current, a moving negative charge, *i. e.*, a stream of electrons; effects of this current—heat (as in the electric light), chemical action (as in batteries and electro-plating), and magnetism (as in the electric bell).
3. The electromagnet: Electric bells; magnetic clocks; magnetic door-latch; telegraph sounders and relays; spark coils; transformers; telephones, etc.; the magnetic path and magnetic poles; importance of the material of the path—permeability and retentivity; the rule for polarity of electromagnet; the

magnetic field around a magnet; the field around a straight wire; the right-hand rule; strength of field; the core of steel a permanent magnet.

4. Permanent magnets: How made; uses of permanent magnets; shapes of permanent magnets, and reason therefor; the earth a magnet; the compass; usefulness of the compass; declination and magnetic maps.
5. Electrical resistance: Unit of resistance: units of current and potential difference; measurement of electrical resistance; its commercial importance; factors determining resistance; transmitting electric power; house wiring; loss of power in the wires and method of measuring and calculating this; methods of diminishing this loss.
6. Heating and lighting by electric current: Light only from heat; why the lamp filament gives light; amount of heat produced; kinds of electric lamps and their relative uses and merits—lamp efficiency; sizes of lamps; the gas-filled lamp; electric cooking—toasters, grills, stoves, ranges; other heating devices—flatirons, curling irons, soldering irons, hair-dryers; advantages and disadvantages of electricity for heat.
7. Electricity for chemical uses: Electroplating; hydrogen and oxygen by means of electric current—electrolysis, electrotyping; the storage battery; accidental electrolysis, as from car tracks to water or gas pipes, and vice versa; production of ozone.
8. Methods of obtaining electricity: Cells of various kinds; theory of the "voltaic cell"; local action; polarization; the dry cell, materials and depolarization; the gravity cell; the Edison primary; life of a battery; internal resistance; groups of cells in series and parallel.
9. The dynamo: Current by "induction"; "cutting" lines of magnetic force; electric charge produced on wire; p. d. between its ends; factors determining amount of p. d.; "electromotive force"; the important characteristics of both dynamo and battery; how dynamos are rated; importance of steady voltage and methods of regulating it; direct and alternating current; the commutator; the magnetic circuit of a dynamo; "compounding" a dynamo; dynamo speed; sizes of dynamos; methods of driving dynamos; dynamo efficiency; sources of

loss of energy in the dynamo; starting the dynamo to "generating."

10. The electric motor: Any dynamo a motor at the same time; an electric current in a magnetic field; Lenz's law; direction of the motion; amount of the force; self-regulation of the current in a motor—back e.m.f.; series and shunt motors, and their respective uses and advantages.
11. The transformer and induction coil: Conditions for an induced voltage; a changing magnetic field; varying the magnetizing current; "make and break" and the alternating current; the spark coil; uses and disadvantages; efficiency; the transformer; great advantage of the closed magnetic path; commercial importance of the transformer, and the reason therefor; efficiency of the transformer.
12. The telephone: The receiver—effect of sending a rapidly varying current through it; the voice of the speaker produces this varying current; method by which this is accomplished—the transmitter; the central exchange; party lines and multiple ringing; correct use of the telephone.

VII. Sound.

1. What is sound? Sounding things are in rapid vibration; experimental proof of speed of sound—see steam vapor from a distant whistle before hearing the sound of the whistle or seeing a blow fall before hearing the sound of it; factors determining speed of sound in anything; a sound wave, and how it travels; condensations and rarefactions.
2. Reflection of sound waves: Better hearing in room than out of doors; echoes in large auditoriums,—the "acoustics" of an auditorium, and what determines its character; methods of correction; absorption of sound by porous substances, like clothing, draperies, carpets, rugs.
3. Directing of sound: Speaking tubes, megaphones; proper shape of a megaphone; reflection from curved surfaces, as at the back of some stages or bandstands; sound going around corners and edges.
4. Music: What is music? The musical scale; chords; pitch; harmony; effect of pitch on brilliancy of music; present pitch numbers in music; sympathetic vibrations; resonance, as by calling certain note into piano box; vibrating strings, as in

piano, violin, guitar, banjo; factors determining pitch of vibrating strings; tuning instruments; the process of piano tuning; factors determining this. Air column instruments, the pipe-organ, horns, the flute, the clarinet. Factors determining the pitch given out by an air column; how these instruments obtain the different notes. Vibrating reed instruments, concertina, reed organ, harmonica—how they operate.

5. The talking machine: The record; how it is made; its surface; the sound-box, and how it operates; effect of length of needle; effect of speed of rotation of record; regulating the speed; the horn; limitations of the talking machine.

VIII. Light.

1. What is light? How we see; reflection of light, as from a light wall surface; absorption of light, as by a dark wall surface; light a wave motion in the ether; speed of light.
2. Room lighting: Natural lighting—size, number, and location of windows; lighting of schoolroom—direction from which light comes, relation of window area to floor area, height of windows; tempering direct sunlight; value of direct sunlight. Artificial lighting—size, number, and location of sources; importance of avoiding glare; intensity of light; foot-candle; lumen; light measurement; the candlepower; proper kind of reflectors; floor plan showing location of lamps and switches.
3. Direct reflection: Searchlights, head-lights, mirrors; formation of images by reflection; real and virtual images; periscopes.
4. Lenses: Cameras, opera glasses, field glasses, telescopes, microscopes, projection lanterns, magnifying glasses, stereoscopes.
5. Color: Colors of objects in sunlight and artificial light; the spectrum; mixing color pigments; color printing; color photography; color and black-and-white photography.

IX. Radio Activity.

1. Cathode rays: X-rays; X-ray tube; usefulness of the X-ray; X-ray pictures; method of operation; precautions; the fluoroscope.
2. Wireless transmission of energy: Hertz's discovery; an electromagnetic wave, how produced; characteristics of these waves;

wave length and frequency, and their control; damped and undamped wave and methods of same; layout of sending plant; layout of receiving set; the vacuum electrode; wireless range, and its determining factors. Wireless telephony.

3. Radioactive materials: The radioactive theory.

STUDY NO. 14C

Some Facts Regarding Sex Instruction in the High Schools in the United States

By Newell W. Edson*

Problem.—(1) To ascertain the facts about the number and distribution of high schools giving sex instruction through regular subjects of the curriculum; (2) to learn the content and method of such parts of such school subjects as relate to sex instruction and guidance; (3) to discover the attitude of the principals toward sex instruction in high schools.

Method.—In January, 1920, the United States Bureau of Education and the United States Public Health Service sent out a questionary to 12,025 accredited and partly accredited high schools in the United States. Replies were received from 6488 (53.8 per cent).

Findings.—(1) Sixteen hundred thirty-three high schools replying give emergency sex instruction, that is, through lectures, occasional talks, sex hygiene exhibits, pamphlets, etc.; 1005 give integrated sex education, that is, incidentally in the subjects of the regular curriculum; 3850 give no sex education. "From the number of attempts in the field of sex education, experimental in character because of the

* *The School Review*, October, 1921. Vol. XXIX, pp. 593–602. A report of the same study under the title, "The Status of Sex Education in the High Schools of the United States," is found in the *General Science Quarterly*, November, 1924. Vol. IX, pp. 52–58.

absence of standard content or method, and from the expressed attitude of high school principals, there appears a rather widespread belief that sex education is needed."

2. ". . . sex instruction is not limited to large city schools but has sprung up in schools of all sizes in communities of all sizes." "Among the various states there is no uniformity in the ratio of schools giving and those not giving sex education."

3. "Apparently, sex instruction has developed here and there without regard to locality, an indication that it has grown because of genuine need. Nor is it likely that its status is a result of propaganda. Indeed, the movement is too new and has too little uniformity . . ."

4. "The West has apparently progressed further in developing sex education than have other sections of the country."

5. "Not all school subjects are equally adapted to serve as media for sex facts." Some phases of sex education can be handled normally as part of a particular subject or of several subjects, while a wide variety of subjects may serve for presenting at least one phase of sex education.

6. Because of their frequent dealing with sex and reproduction in plants and animals, the biological sciences furnish the readiest vehicles for sex education. Sociology, physiology, hygiene, which in its fact content is mainly biology, and physical education are possible avenues of approach—utilized, however, by but few teachers.

7. "Aside from dealing with topics of human reproduction and venereal diseases, there is little organized sex instruction in connection with established high school subjects."

8. Sex instruction is probably given early in the high school course because the subjects including it happen to

be taught then, rather than because of a conscious plan to give such instruction in early adolescence when it is most needed.

9. Principals expressed marked approval of integrated sex education, voicing their conviction of the success of such instruction as has been given.

10. "Emergency sex education, . . . has less approval than sex education given as part of the regular subjects in the curriculum."

11. "There is apparently as yet no marked realization on the part of principals that sex education should include both instruction and guidance in matters pertaining to relationships between the two sexes."

12. "An exchange of experience among different schools would undoubtedly allow many well-qualified teachers who are holding back now for lack of knowledge of method, to go ahead with sex instruction and guidance."

STUDY NO. 15C

A Quantitative Analysis of General Science Texts
By Hanor A. Webb*

UNIT I

Problem.—To determine (1) the distribution of subject matter in text-books of general science as indicated by the number of pages devoted to instruction in each of eight large science groups, namely, astronomy, biology (botany-zoology), chemistry, household arts, physics, physiography, physiology (hygiene), miscellaneous; and (2) the relative number and importance of topics in these science groups,

* Doctor's thesis. *General Science Instruction in the Grades: Part I.* Contributions to Education, No. 4, Nashville, Tennessee: George Peabody College for Teachers, 1921. pp. 1–40.

as indicated by the number of text-books including each topic, and by the number of pages devoted to it.

Method.—In the spring of 1919, 18 text-books containing 6638 pages of instruction excluding tables of contents, introductions, prefaces, general review questions, appendices and indices were analyzed page by page, and an entry was made on a card for every half-page; each card was labeled with the title of the topic best designating the subject of the material presented, with the name of the book, and the page number of the topic. "The cards were then arranged under headings of generally recognized branches of scientific knowledge, then rearranged under important topics in each of these special sciences." The best possible individual judgment was used in each case in deciding the topic names and the specific science under which each topic should go. "Closely related topics were grouped to reduce the number of units to be handled," for example, "Transfer of Heat (Radiation, Conduction, Convection, and Applications)."

Findings.—(1) The specific sciences mentioned (astronomy, botany, chemistry, . . . zoology) furnish 98.2 per cent of the material included in text-books of general science now in use (1919). "In every science except zoology, over half the pages of instruction were devoted to discussion of topics which were found in a majority of the other texts." "General science is [therefore] by no means a mass of unrelated subject matter; there is [moreover] a recognition of acceptability of a large mass of subject matter of the so-called 'special sciences' by the authors of these texts."

TABLE III

PER CENT OF SUBJECT MATTER DEVOTED TO VARIOUS SCIENCES IN 10 OR MORE TEXT-BOOKS OF GENERAL SCIENCE (WEBB STUDY)

Science	Per cent by pages	Per cent by topics	Science	Per cent by pages	Per cent by topics
Physiography[1].	80.5	47.8	Chemistry....	64.5	34.2
Physics.....	80.3	54.4	Botany.....	63.1	43.5
Physiology....	72.6	33.3	Household art	56.6	15.4
Astronomy....	70.2	40.0	Zoology.....	0.	0.

[1] The items of this table would be worded as follows: "In physiography, 80.5 per cent of the space, and 47.8 per cent of the distinct topics, are devoted to subject matter found in a majority (10 or more) of the text-books," etc.

2. "The rank of physics, as most important in the matter of space devoted to topics, is indisputable. The deviations of this science from first rank in the texts are almost negligible. The agreement as to the ranks of the other sciences is less unanimous but uniform, that is, the deviations from median rank are practically the same. Even physiology which most greatly varies in importance assigned to it by various authors shows a median deviation of only 1.5 ranks either way."

TABLE IV

THE TOPICS OF GENERAL SCIENCE (WEBB STUDY)

Topic	Number of books	Number of pages
I. In physics		
1. Transfer of heat (radiation, conduction, convection, and applications)	18	252.5
2. Thermometers	18	84.5
3. Air pressure and measurement. Barometers	17	154
4. Energy, types of. Momentum, inertia, etc.	15	82
5. Three molecular states of matter	15	64
6. Quantity of heat. Specific heat	15	54
7. Levers	14	55
8. Magnets, permanent	13	66.5
9. Specific gravity, buoyancy, etc.	13	43.5
10. Pumps and their uses	13	43
11. Reflection of light. Mirrors	13	39
12. The inclined plane	13	37
13. Mass or weight of matter. Gravity	13	32.5
14. The spectrum. Rainbows, etc.	13	28.5
15. Electromagnets and applications	12	56.5
16. Boiling and freezing points	12	56.5
17. Ice making, principle of	12	54.5
18. Refraction of light. Lenses, etc.	12	45
19. Electrical cells	12	34
20. Dynamos and motors	11	48
21. The steam engine	11	39
22. Expansion from heat	11	38
23. Nature of light	11	38
24. Artificial lighting, principles of	10	71
25. Sound	10	58
26. Water and wind power	10	50
27. Electric heating and lighting	10	38.5
28. Liquid pressure, laws of. Hydraulics	10	38.5

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
29. Evaporation. Vapor pressure	10	29
30. Solutions. Physical properties of water	10	24.5
31. Pulleys	10	22
32. Static electricity	9	29.5
33. Friction producing heat	9	18.5
34. Distillation	9	14.5
35. Electroplating	9	13.5
36. Siphons	9	8.5
37. Weights and measures	8	53
38. Cohesion and adhesion. Capillarity	8	21.5
39. Gasoline engine	8	21
40. Heat, theoretical nature of	8	17.5
41. Machines and their applications	7	65
42. Resolution of forces. Kites, airplanes, etc	7	42
43. Diffusion of gases. Kinetic molecular hypothesis	7	11.5
44. Insolation. Absorption of heat by air	6	13.5
45. Units of electrical measure	5	11
46. Color, theory of	5	11
47. Storage batteries	4	7
48. Explosions. Energy of expanding gases	4	5.5
49. Electrical appliances, fuses, switches, etc	3	21
50. Electrical transformers	3	7
51. The pendulum	2	9
52. Bridges, construction of	1	8.5
53. Physical laws, general definition	1	1.5
54. Angular measurement	1	1.5
55. Hardness of substances, scale of	1	1
56. Absorption of gases	1	.5
Total pages of topics in physics		2212.5

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
II. In physiography		
1. Humidity. Precipitation of all kinds	17	181.5
2. Winds and storms, causes of	17	178
3. Soil formation. Weathering. Types	16	145.5
4. Weather forecasts, and weather maps	16	93
5. Ground water, caves, springs, etc	14	65.5
6. Erosion, deposition, rivers, lakes	13	127.5
7. Irrigation, drainage	13	40.5
8. Coal, occurrence and formation	13	26
9. Climate, conditions and causes	11	62
10. Rocks, igneous and sedimentary	10	80.5
11. Thunder storms. Lightning	10	18
12. Tillage of the soil, effects of	6	25.5
13. Oil wells, petroleum, natural gas, etc	6	23.5
14. Glaciers, icebergs	5	37
15. Volcanoes, earthquakes	4	31
16. Mountains, how formed	4	29.5
17. Land forms, coast lines, bays, etc	3	55
18. The ocean. Currents, etc	3	20
19. The earth's crust	3	8
20. Topographical maps, rules for making	2	12.5
21. Mines, their construction. Mining	2	3
22. The aurora borealis	2	1.5
Total pages of topics in physiography		1264.5
III. In biology—Botany		
1. Photosynthesis	16	68
2. Yeasts and molds	16	60.5
3. Flowers, structure and function	15	46.5
4. Roots, structure and function. Osmosis	14	46.5
5. Bacteria. Fixation of nitrogen	14	31
6. Seeds, dispersal, germination	13	39.5
7. Stems, trees as types	12	69.5

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
8. Bacteria, structure of (not hygiene)	10	33.5
9. Leaves, structure of	10	27
10. Transpiration	10	24
11. Cells, protoplasm	8	23.5
12. Fertilizers and plant foods	7	32
13. Plant life, miscellaneous types	7	16.5
14. Distribution and variety of plants	6	38.5
15. Artificial plant propagation. Budding, grafting, etc	6	22
16. Higher Fungi, toadstools, etc	6	14
17. Heredity. Natural and artificial selection	5	49.5
18. Algae	5	17
19. Gardening and cultivation of plants	4	29
20. Ferns and mosses	4	6
21. Plant diseases	3	11.5
22. Sap of plants, juices, etc	2	2
Zoology		
23. Insects	9	34.5
24. Types of animals. Vertebrates, invertebrates	6	34
25. Amphibians. Life history of frog	6	12.5
26. Amoeba	6	12
27. Animal distribution over the earth	5	28.5
28. Birds	5	16
29. Fish	4	7.5
30. Reproduction in animals	4	6.5
31. Worms	4	5
32. Mammals	4	4.5
33. Animals useful and harmful to man	3	12.5
34. Reptiles	3	2
35. Animal parasites and pests	2	13
36. Low forms of animal life. Hydra, coral	2	4.5

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
37. Crayfish	2	4
38. Mollusks	2	3
39. Instinct	2	1
Total pages of topics in biology		908.0
IV. In physiology-hygiene		
1. Bacteria and contagious diseases	15	206
2. Pure water supply, how obtained	15	98
3. Insect carriers of disease	13	54.5
4. Respiration	13	50.5
5. Digestion	12	79.5
6. The eye	12	60
7. Narcotics and stimulants	12	52
8. The circulation	10	42
9. Sewage disposal	7	35.5
10. The nervous system	7	32.5
11. The ear	7	13
12. First aid	6	34.5
13. The skeleton. Bones	6	21.5
14. Excretion	5	23.5
15. Muscles	5	13.5
16. Pure air. Harmfulness of dust	5	12
17. Sanitary plumbing	4	17.5
18. Hygiene, miscellaneous discussion of	3	26.5
19. Animal parasites, tapeworm, hookworm	3	2.5
20. The special senses, miscellaneous	2	3.5
21. Touch	2	2
22. Taste	2	1.5
23. Smell	2	1
24. Ductless glands	1	2.5
Total pages of topics in physiology-hygiene		885.5

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
V. In chemistry		
1. Combustion	18	75.5
2. Composition of the atmosphere	16	38
3. Oxygen, occurrence, preparation, etc	14	37
4. Carbon dioxide, preparation, etc	14	28
5. Composition of water. Electrolysis	13	20
6. Elements, mixtures, and compounds	12	33.5
7. Hydrogen, preparation and properties	12	23.5
8. Hardness of water	12	14.5
9. Physical and chemical changes	11	31
10. Nitrogen, preparation and properties	11	12.5
11. Acids, bases, and salts	10	50.5
12. Solution and crystallization	10	24.5
13. Phosphorus. Matches	10	19
14. Useful metals, metallurgy	9	63.5
15. Photography	9	25
16. Carbon, its forms and uses	9	24
17. Destructive distillation of wood and coal	9	17.5
18. Baking powders, chemical action of	8	17.5
19. Fuels, chemical nature of	6	27
20. Sulfur	4	8.5
21. Paints and oils	4	8
22. Chlorine, preparation and properties	4	6
23. Glass, manufacture of	3	7
24. Lime, cement, and clay	3	6.5
25. Alloys	3	1.5
26. Conservation of matter, law of	2	2.5
27. Ammonia, preparation and properties	2	2
28. Fireproofing and waterproofing	1	2.5
29. Deliquescence and efflorescence	1	1.5
30. Phosphorescence, as in fireflies	1	1
31. Flocculation	1	1

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
32. Distinction between organic and inorganic chemistry	1	1
33. Law of definite proportions	1	1
Total pages of topics in chemistry		632.0
VI. In household arts and science		
1. Composition of foods. Carbohydrates, proteins, fats	15	118
2. Fuel value of foods. Dietary	11	76.5
3. Preservation of foods	7	27.5
4. Cleansing of textiles	6	28
5. Textiles and clothing	6	17
6. Effect of cooking on foods	6	17
7. Soap making	5	17.5
8. Food, adulteration of	3	15
9. Dyeing	3	5.5
10. Household management	2	10
11. Bread making	2	9.5
12. Flavoring extracts and perfumes	2	1.5
13. Paper making	1	.5
Total pages of topics in household arts and science		343.5
VII. In astronomy		
1. The solar system, sun and planets	13	67
2. The seasons	13	36.5
3. The stars and constellations	10	50.5
4. The earth as a planet	10	36.5
5. The moon. Eclipses	8	30.5
6. Time	8	17.5
7. Latitude and longitude	6	20
8. The tides	4	7

TABLE IV (*Continued*)

Topic	Number of books	Number of pages
9. Comets	3	3.5
10. Meteors	3	2.5
Total pages of topics in astronomy		271.5
VIII. In miscellaneous topics		
1. Value and method of science study	8	40.5
2. World commerce and transportation	5	41.5
3. Man's relation to nature	4	12
4. Economic problems, wages, industry, etc.	1	11.5
5. Prehistoric man	1	6½
6. Psychology. The mind	1	3
7. Principles of civilization	1	3
8. Economy in the home, general	1	1.5
9. Drawing, the art of	1	1.5
Total pages of miscellaneous topics		120.5
Total number of pages classified		6638.0

3. "The treatment accorded to household art and astronomy is decidedly superficial."

4. "The small amount of space devoted to miscellaneous topics is another contradiction of the claim that much of general science could not be classified under headings of more familiar and established branches of scientific knowledge."

UNIT II

Problem.—To determine quantitatively the acceptability of the various topics of general science.

Method.—An Acceptability Factor was devised with the following formula: Acceptability Factor $= \frac{t^2 p}{TP}$, where $t =$ the number of text-books in which the topic occurs; T,

the total number of text-books (18); p, the number of pages devoted to the topic in a certain text-book; and P, the number of pages devoted to the topic in all texts. The Acceptability Factor was computed for each of the 1557 unit topics of the 18 text-books in general science.

If a topic received uniform treatment in all text-books, whether a large or small amount of space, the Acceptability Factor as computed by this formula would equal unity. The Factor would be greater than 1 for a topic in a certain text which received marked prominence as to space, and which is included in all, or nearly all, texts. The Factor would be less than 1 for a topic in a certain text which is given little prominence in that text, or which occurs in only a few texts.

"A text with a high average Acceptability Factor . . . contains topics which have been considered important by most of the *other* authors of general science texts . . . A text with a low average Acceptability Factor . . . has emphasized topics not considered important by *other* authors of general science texts, and has omitted, or superficially treated, the topics which are generally included by the other authors. Depending upon the point of view, such a text would be commended for its originality, or criticized as a freak. It is at least *sui generis*."

Each science may be expected to have a high or low average Acceptability Factor in proportion to the agreement or disagreement among authors of text-books of general science as to the most characteristic and suitable topics of that science.

Findings.—(1) If the judgment of the investigator be accepted, that an Acceptability Factor of .500 or over indicates satisfactory agreement as to the suitability of a topic, or if that value as the average for the topics of a text

or science represents a general suitability of the topic selected, it then appears that with the exception of household arts and zoology there is a fairly well-established agreement among the authors of general science as to what subject matter is appropriate.

2. "Only six text-books show a tendency to select material far afield. This agreement is more striking because the judgments of the authors have been made independently over a period of many years. General science as a whole cannot be considered as a hodge-podge of unrelated topics, selected by irresponsible whims."

TABLE V

ACCEPTABILITY FACTORS OF SCIENCES (WEBB STUDY)

Science	Acceptability factor	Science	Acceptability factor
Physiography	.670	Astronomy	.524
Physics	.631	Household arts	.464
Botany	.603	Zoology	.288
Chemistry	.601	Miscellaneous	.280
Physiology	.547		

UNIT III

Problem.—To determine the size of undivided topics in text books in general science.

Method.—The number of pages (in multiples of half-pages) devoted continuously to a single topic, was taken from the cards on which were the original entries made in examining the 18 text-books. These were considered not only with respect to typical size of continuously treated topics, but also with respect to the distribution of these sizes above and below the median, "since two text-books might show the same value for a median size of their topics

but the separate measures of one text might conform closely to this central tendency while those of another text-book varied widely from it."

Findings.—(1) General science is presented in the form of small unit topics of 2 or 3 pages in extent. The highest median in any text or science is only 7.5 pages. Of 2214 continuous topics in 18 text-books, only 71 are in excess of 10 pages and only 14 in excess of 20. The median deviation is rarely over 2 pages, usually 1 page or less. Only 4 text-books out of 18 and only 1 science (physiography) contain topics of median size of 3 pages or more.

2. "It is apparent that the authors of general science texts are in decided agreement concerning this phase of presentation of their subject matter."

UNIT IV

Problem.—To determine by quantitative measurement the evenness of distribution which may be characteristic of each special science in each of the 18 text-books.

Method.—The text-books were divided each into 10 equal portions; each portion contained from 0 per cent to 100 per cent of the subject matter of a particular science in that text-book. "An ideal distribution would be found if 10 per cent of the space allotted to the science should occur in each of the 10 portions—in fact, this would obviously be 100 per cent distributed—that is, as widely distributed as possible. On the other extreme, if all of the discussion of a certain science should be concentrated into one of the $\frac{1}{10}$ portions where only 10 per cent of it should be found, it is obvious that only 10 per cent of the distribution is correct.

"The arbitrary selection of 10 divisions merely gives a convenient and appropriate fractional part; any other portion would have been usuable. Smaller divisions would

give more refined data, but extreme minutiae would have been little, if any, more instructive in the tables which have been computed."

The formula is *Per Cent or Distribution* $= \frac{100{,}000}{S(\%^2)}$, in which $S(\%)$ represents the sum of the separate per cents of a science in each of the $\frac{1}{10}$ portions of a text.

Findings.—(1) "It appears that the authors of general science have found it least difficult to scatter the subject matter of physics over the pages of their texts, linking phenomena of that science with topics of others." The average rank for the distribution of physics (52.4 per cent) greatly exceeds that of the next highest science, physiography (33.5 per cent), showing that in this and the remaining sciences a condition of real "general" distribution is not even approached. "This is not due to any purely accidental value for the averages calculated; for when the distributions for the sciences in each text are averaged, a remarkable uniformity of treatment is disclosed." ". . . no author has radically departed from the established method of grouping the fields of science under the traditional headings."

TABLE VI

PER CENT OF DISTRIBUTION FOR SCIENCES (WEBB STUDY)

Science	Per cent distribution		Science	Per cent distribution	
	Average	Median		Average	Median
Physics	52.4	57.7	Household arts	24.8	21.4
Physiography	33.5	32.1	Biology	24.7	25.2
Physiology	32.2	29.7	Astronomy	18.4	15.1
Chemistry	29.7	30.6	Miscellaneous	17.9	15.1

UNIT V

Problem.—To determine the correlations between the sciences as to (1) space in text-books, (2) per cent of distribution in the 18 text-books, (3) number of pages and per cent of distribution of each science, and (4) the Acceptability Factors in the text-books.

Method.—Pearson's formula for computing the Coefficient of Correlation was used to show the relationships of the sciences in pairs. "Strong positive correlation would indicate a 'pairing' of the two sciences, exerting mutual influence over each other's rank. Any author who gave a large space to one would give a proportionally large space to the other, and vice versa."

Strong negative correlation would indicate antagonism between the two sciences, and an inverse ratio as to the space received. Weak correlations would indicate the lack of any fundameneal relationship between two sciences, the ranks and quantities of each science being independent of the other."

Findings.—(1) With respect to correlation between the sciences as to space in the text-books, most of the values are low; only the correlation between physics and chemistry (+.517) and between physics and household arts (+.590) are sufficiently strong to indicate a pairing. "In respect to all other pairs, the absence of any general underlying principles of coordination between the sciences in determining the amount of space they are given in the general science text-books is demonstrated."

2. "The values of these correlations between the sciences as to the space given to each are too low to admit of strong positive interpretations. The close agreement of the averages for the texts is evidently due to compensating values

for different distributions which each science received in the 18 texts. The present status as to distribution clearly is one of individualism."

3. "In those text-books where other sciences are widely scattered, physiography was through some necessity concentrated, and vice versa."

4. The correlations between the number of pages and the per cent of distribution in each science are positive in six sciences, and negative in two, all but one being low in value. "This exception is in the science, biology (+.536) of which it is characteristic that the texts giving the science most space tend to distribute it most thoroughly. This tendency, however, cannot be characteristic of general science as a whole, or the correlations in each science would have been more strongly positive."

5. Correlating the ranks of the sciences as to the per cent of space occupied and the percentage distribution in each text separately by Spearman's Rank Order Formula further emphasized the conclusion that "no matter how much unity of plan an individual author may embody in his text, his arrangement is individual and original and general science as a whole is not unified [as to order of topics, or arrangement]."

6. With respect to correlations between the sciences as to Acceptability Factors, 10 strongly positive values (over +.500) and 5 moderate (between +.400 and +.500) out of 25 positive values "indicate a strong tendency for the conservative text-book to make equally appropriate selections of topics of each important science; a poor, or bizarre text, to be uniformly unconventional. The former tendency is the principal one, since 12 of the 18 text-books have Acceptability Factors above +.500. If general science were a hodge-podge of unrelated topics, the Acceptability Factor

would be exceedingly low and the correlations close to zero [a condition which is not found]."

STUDY NO. 16C

The Reaction of Children of the Last Three Grammar Grades to Science

By Hanor A. Webb*

UNIT I

Problem.—To determine the adaptability of general science in the last three grammar grades.

Method.—From the tabulated data of the preceding study (Part I),[1] 25 important and characteristic topics were selected from each of the 5 principal sciences (as shown by the content in 18 general science text-books analyzed), physics, physiography, biology, physiology-hygiene, and chemistry. Only those topics were considered which were found in a clear majority of the text-books, and since in the zoology section of biology no topics were included in at least 10 text-books, the 5 leading topics were chosen from zoology and 20 were added from botany to complete the quota in biology.

The particular facts of science upon which the statements of the test topics were based, were selected on the basis of the number of text-books in which each was discussed, as determined from a careful consideration of the data used in Part I.[1] The most important sub-topic in each of 25

* Doctor's thesis. *General Science Instruction in the Grades: Part II.* Contributions to Education, No. 4, Nashville, Tennessee: George Peabody College for Teachers, 1921. pp. 41–105.

[1] Study No. 15C.

most highly ranked topics in physics was selected, and in the cases of other subjects of which the majority of topics were not contained in at least 10 of the text-books, 2 or more sub topics were chosen from each topic having the greatest number of pages. The selection in all of 125 test topics, 25 from each of the principal sciences, resulted in the selection of test topics thoroughly characteristic of each science, each topic representing the most favorable judgment of more than a majority of the authors of general science text-books as to its fitness to be presented as a part of instruction in the text-book.

Following a special study of the text-books as to the language and treatment of each selected topic, a four-page folder was made for each topic chosen: Page 1 gave directions to the pupil. Page 2, designed to discover whether the child had already possessed a knowledge of the principles of the test-topic, contained a question which was direct and simple and which usually covered one point only. "If answered correctly, it would be evident that the child possessed some apperceptive basis for the further consideration of the particular topic involved. If answered incorrectly, it would appear that the child either had no previous conception of the subject or was unable to express one. The data obtained from the answers to this question were expected to be a measure of the foundation of previous knowledge upon which instruction in general science in the grades might be built."

Page 3 gave a direct statement (accompanied by illustrations in 35 instances), in which the facts and principles of the test topic were set forth as clearly and simply as possible. The statement was carefully worded after a study of each text.

Page 4 gave "one or more direct questions, calling for the specific information given on the preceding page. A correct answer would be evidence that the child is capable of understanding the subject matter of the statement; and the further inference is not unreasonable that similar statements, equally characteristic of the science and of approximately the same degree of complexity, might also be assimilated by the child. An incorrect answer, or no answer, might indicate that the topic was apparently too complicated for the child's understanding, and that he would probably have difficulty or fail completely in the assimilation of similar topics in that science."

Page 4B gave "one or more questions, based on the specific information of the statement on page 3, but involving a further step of reasoning along some closely related line. A correct answer would indicate that the child not only understood the topic, but was able to apply its principles to the solution of another problem such as might be next propounded by the text or teacher in ordinary recitation. An incorrect answer would warrant the conclusion that the principles of the statement, even if understood by the child, were in isolated position in his mind and not sufficiently correlated with his apperceptions to be of practical value."

"Special effort was made to avoid questions which could be answered by mere 'yes' or 'no,' or in which the choice of one alternative without explanation would suffice. The use of such words as 'explain,' 'illustrate,' etc., was discarded in favor of the simpler phrases, 'Tell about it,' 'What is,' etc."

Letters were sent to 120 superintendents of schools in towns of not more than 10,000 or less than 5,000 as given in the Educational Directory for 1918. Sixty-two agreed to distribute the material to their teachers for use; 40 superintendents in 18 states returned 9,819 sets out of 19,000 sent

out. The tests received represented a very fair sampling both for the grades tested and for the five branches of science represented in the test questions. In each of the six grade groups represented (fifth, sixth, seventh in some schools and sixth, seventh, and eighth in others) the children answered the questions related to five sciences under 25 topics, hence the results were recorded under 750 distinct question groups, each constituting the number of answers received for one text topic of one science in one grade; the normal distribution curve for the number of unit groups answered was closely approximated, showing the efforts to secure a perfectly random distribution to have been entirely successful.

"In marking the tests, 'A' represents the correct answer in which the pupil displays a reasonable understanding of the topic and expresses the idea in the manner which would be acceptable to the average teacher. 'B' represents decidedly inferior answer, hazy conception evidenced by faulty or incomplete expression leaving doubt whether there is really an appreciable understanding. The germ of the idea is recognizable, however. 'C' represents an incorrect answer or no answer at all." Thus the mark ACB for a given item would indicate satisfactory (A) *previous knowledge* of the item, no (C) *ability to assimilate* in so far as this particular item is concerned, and an inferior (B) *power to apply* the idea bound up in the item. Since the time allowed for studying and writing the test (determined by some preliminary experiments in the Demonstration School of George Peabody College for Teachers) proved to be generous, "the lack of an attempt was reasonably interpreted as inability on the part of the pupil to answer."

All the 29,457 questions were individually marked by the experimenter in unsorted order, just as received, to avoid

his mind's getting into a certain "track" in marking large numbers of identical questions. The marking was done almost continuously, day after day, for the sake of keeping the point of view reasonably constant throughout the whole time. No tabulations of any kind were made until after all the marking had been completed.

Only 38 grade pupils tested had had a course in general science, and when a comparison of their marks with those of others in the same school and grade showed no appreciable differences, the papers were included in the general distribution. The results were analyzed first by numerical count and then by per cent of A's, B's, and C's for each question for each unit group. The 25 groups comprising all the questions in one science answered by children of one grade were ranked, and the quartiles, medians, and averages were determined: "these figures represent the characteristic reaction of children in each separate group to each separate science."

The variation in the numbers of answers for different topics, for the different sciences, and for the different grades were equalized by the use of percentages instead of numerical counts of A's, B's, and C's, and the medians were used instead of the averages to eliminate the effect of widely variant results.

Findings.—(1) A representative list of the principles of the specific sciences (astromony, botany, chemistry, . . . zoology) which furnish 98.2 per cent of the material included in general science text-books (in 1919) cannot be effectively presented to children below the sixth grade. These children lack a sufficient apperceptive foundation of previous experience; they are not able directly to assimilate and to express again any reasonable number of characteristic

ideas of science; their minds have not sufficiently developed so that powers of logical reasoning may be expected.

2. In the sixth grade, physiology and physiography alone seem to offer suitable materials for instruction in science. "There is a reasonable amount of previous knowledge possessed by children in this grade, and the characteristic and fundamental topics of these sciences seem to be satisfactorily assimilated and logically applied according to the standards suggested."

3. "In the seventh grade, biology, and possibly a most elementary treatment of physics, becomes appropiate according to similar standards."

4. "In the eighth grade, physics is acceptable for instruction according to similar standards."

5. "Chemistry is of doubtful value for instruction in any of the grammar grades, since its percentages in previous knowledge, direct assimilation, and power of application, all fall below the suggested standards, which are easily attained by children of some grade or grades in the other sciences."

UNIT II

Problem.—To determine what were the guiding influences on the reactions of children, their causes and possible significances, as shown by the answers to the questions testing (1) previous knowledge, (2) ability to assimilate plain statements, and (3) power to apply information.

Method.—The A, B, C marks of the test were ranked with respect to their 27 possible combinations for each science in each grade. A study of each distribution was made and particular attention was paid to the following points:

(1). "The amount of concentration of marks under a few combinations—a condition indicated by the height of

the upper quartile and the median. The ranks of the combinations below the median are not of much significance."

(2). The predominance of A's, B's, or C's in the combinations above the median, and their occurrence in connection with the questions on the previous knowledge, direct assimilation, or power of application.

(3). The rank of the perfect mark (AAA) and of complete failure (CCC).

Findings.—(1) "It appears that the extremely poor reaction of fifth-grade children to the presentation of characteristic topics of science is largely due to a lack of previous experience which might be utilized as an apperceptive basis."

2. "Children of the sixth grade give satisfactory response only to physiology-hygiene and physiography, except as to their previous knowledge, in which they are still deficient. The other sciences cannot be considered suitable for instruction in this grade."

3. "Children of the seventh grade give satisfactory responses in all sciences except chemistry, although physics still presents serious difficulties. In physiography, biology, and physics the good showing is made in spite of the small amount of previous knowledge which is but little, if any, greater than that possessed by children of the sixth grade. The ability to make applications has considerably increased in the seventh grade."

4. "Children of the eighth grade give satisfactory reactions to all sciences except chemistry. The children have not yet acquired, however, or have been unable to classify, the amount of previous experience which would seem desirable for best results in learning a science; but the condition is far better in the eighth grade than in any previous one."

5. "The reaction to physiology-hygiene is good except in the fifth grade; previous knowledge [of physiology-hygiene] is fair only in the seventh and eighth grades." Physiology-hygiene is obviously the most suitable of all the sciences for instruction in the grades.

6. The suitability of physiography as subject-matter for the sixth grade would be established were it not for the presence of a large number of failures. "With the elimination of the failures above the median in the seventh grade, the reaction becomes excellent."

7. "Biology in the fifth and sixth grades is less satisfactory than physiography," but "is obviously suitable as a source of topics for instruction in the seventh and eighth grades."

8. "In physics even a fair reaction cannot be claimed until the seventh grade." "The topics of physics seem to be appropriate for instruction in the eighth grade."

9. "The reaction to chemistry is poor in every grade. It can hardly be called fair even in the eighth grade." "The low rank of the better combinations [of ABC marks] rather discourages the inclusion of chemical topics for instruction in any grade."

UNIT III

Problem.—To determine what further light can be thrown on the study by a consideration of the rank and scatter of the 27 combinations, the concentration of answers in certain combinations, the correlations of the ranks of the combinations, and the underlying type for the ranks of the combinations.

Method.—The data was subjected to statistical treatment as a result of which the following formula for "per cent of

scattering" was derived:

$$\textit{Per Cent of Scattering} = \frac{100\ S(d) - \sqrt{S(d^2)}}{(n-1)},$$

in which $S(d)$ represents the sum of the differences in the successive ranks when in rank order, and n the number of ranks. "The per cent of scatter from the average, was calculated for the ranks of each combination in the separate grades [as determined in Unit II], all sciences included, and for each combination in the separate sciences, all grades included." "The 27 combinations were then ranked in each science according to the total number of answers received, disregarding the quota of the different grades." The Coefficients of Correlation were computed (by the Pearson formula) between the ranks of combinations in the different grades in each science, and between the ranks in the different sciences in each grade (in all 195 correlations).

The 27 combinations were then arranged in six different groups representing all possible combinations with respect to the relative importance of the three phases of each combination, (1) previous knowledge, (2) direct assimilation, and (3) power of application. "In order to ascertain which of these six groups most nearly represented the actual performance of the 9819 children of the last three grammar grades who answered the tests, a rank-order correlation (by Spearman's formula) was computed" between the ranks of the 27 combinations in each grade and in each science, and the rank order of the combinations in each of the six groups.

Findings.—(1) "It is apparent that the power of direct assimilation of subject matter . . . is not characteristically preceded by any appreciable amount of previous knowledge, the deficiency of which in these large groups of children is very striking. The power of application seems

to appear suddenly as an acquirement of the larger groups of children in the seventh and eighth grades, this ability being lacking in the fifth and sixth grades."

2. "The general deficiency in previous knowledge, . . . is evident in all sciences. Ability in the power of application . . . is characteristic of these larger groups in certain sciences— physiology, physiography, and biology; but the lack of this power is just as striking for physics and chemistry. Ability in direct assimilation is decidedly prominent in the large groups of children in the same three sciences [physiology, physiography, and biology] and lacking in the same two [physics and chemistry]."

3. "It appears that the reaction of children to a science shows the first evidence of success in response to direct statements and questions, and that both previous knowledge and ability to apply are products of considerable experience. Facts apparently understood from the plain statement of teacher or text are likely to remain isolated, in the mind of a child, and unaccompanied by any previous knowledge or ability to reason in a distressingly large number of cases."

4. "The first power to develop in a child is that of direct assimilation, and this ability keeps ahead in all development. A text in science written for the grades must abound in direct statements of fact, plain illustrative material, and [must] leave little to be inferred. Successful teaching of science in the grades must be judged largely by the extent to which children master the direct assignments of the day. An equivalent success in reasoning from the simple facts learned, must not be expected. A book which is full of the so-called 'thought-questions' is not altogether the best for grade instruction, however applicable that method may be to high school classes. The powers of logical reasoning

have not yet developed in the minds of grade children, and abstract principles cannot be visualized by them."

5. Reliance cannot "be placed on any appreciable previous knowledge possessed by the children. For the grades, science must be even more simple in idea than in language."

6. "The self-acquired knowledge of children goes but little beyond the observation of obvious cause and effect. The much-proclaimed curiosity of children rarely searches out principles. It would seem that the most familiar objects would be the best understood, but the tendency to take familiar things for granted largely neutralizes the spirit of inquiry."

7. "The content [of general science instruction in the grades] should be the most appropriate to the child's environment; but above all, it should be assimilable. Real principles of science are not assimilated by children of the fifth grade and below; physiology and physiography are appropriate in the sixth grade; biology, and possibly physics, may be successfully taught in the seventh grade; physics can be assimilated in the eighth grade; but the laws and phenomena of chemistry seem unsuited to any grade. This order of assimilability is radically different from the rank of the sciences in importance in the 18 texts, most of them for high-school use, in which physics is given the most adequate treatment, and physiography, biology, physiology, and chemistry follow in the order named."

8. "The method of science instruction in the grades should make full use of the predominant power of the child to assimilate facts directly. . . . efforts to cause powers of reason and observation to function when by the laws of child psychology these powers are in a rudimentary stage of development, will result in waste of energy on the part of both teacher and child."

STUDY NO. 17C

Are Any Principles of Organization of General Science Evidenced by the Present Text-books in the Subject?

By Ada L. Weckel*

Problem.—To determine the basic aims, and the underlying scientific principles and fundamental concepts which occur most frequently in text-books in general science.

Method.—The investigator made an analysis of the prefaces and text materials of 14 text-books in general science. She secured the aims from the prefaces, then made a list of the fundamental concepts and topics occurring in first, all 14, then those in only 13, those occurring only in 12, etc., down to those occurring in only 3 of the 14 text-books analyzed. From these data the investigator attempted to formulate a composite course, by placing under the larger units or topics, the fundamental concepts and scientific principles found occurring most frequently in the various text-books.

Findings.—(1) The prefaces of our text-books in general science indicate that the writers recognize these aims:

AIMS OF GENERAL SCIENCE (WECKEL STUDY)

To insure that the pupil acquires:

A. An appreciation of the *applications* of science in industrial and social life;

B. A fund of valuable *information* about nature and sciences;

C. An understanding, an appreciation, and a control of the everyday *environment.*

* *School Science and Mathematics,* January, 1922. Vol. XXII, pp. 44–51.

2. "There is a surprising unanimity in the aims and purposes of general sciences and also in the subject matter included in the courses now given."

THE 89 FUNDAMENTAL CONCEPTS AND TOPICS, AND NUMBER OF TEXT-BOOKS IN WHICH EACH WAS FOUND (WECKEL STUDY)

I. All 14 Text-books

1. Atmospheric pressure
2. Principle of, and kinds of thermometers
3. Definitions and applications of humidity, dew point, condensation, saturation

II. Thirteen of the 14 Text-books

1. Oxidation
2. Transference of heat: Conduction, convection, radiation
3. Soils, origin and composition
4. Study of weather maps

III. Twelve of the 14 Text-books

1. Composition of atmosphere
2. Winds, cause of and general circulation
3. Molds and bacteria: Structure, development, relation to diseases and decay
4. Foods and nutrition

IV. Eleven of the 14 Text-books

1. Study of the cell
2. Calorie, value of
3. Structure and function of parts of human eye
4. Heat, nature and origin
5. Electricity, elementary presentation of
6. Sanitation and diseases: Germs, toxins, antitoxins, disinfectants, sterilization, vaccines, etc.

V. Ten of the 14 Text-books

1. Seasons, cause of
2. Gravity, definition
3. Pumps
4. Storms, causes and common types
5. Sewage disposal
6. Types of electric cells
7. Lighting systems: Kerosene, gas, electric, acetylene

VI. Nine of the 14 Text-books

1. Properties of matter
2. Elements and compounds
3. Plants: Structure and function of root, stem, leaves, flowers
4. Molecular theory
5. Water power and its applications
6. Manufacture of artificial ice
7. Steam engine, principle of action and application
8. Sound, nature of
9. Light, nature of and properties
10. Carbon dioxide: Source, role in nature, fire extinguisher
11. Cell division and reproduction in plants and animals
12. Machines: Lever, screw, pulleys, wheel and axle, inclined plane
13. Solution, especially as applied to hard and soft water
14. Vaporization

VII. Eight of the 14 Text-books

1. Drainage and irrigation
2. Erosion
3. Distillation
4. Solar system
5. Physical and chemical changes
6. Heating systems
7. Magnetism
8. Acids, bases, and neutralization
9. Injurious insects
10. Osmosis
11. Filtration
12. Expansion of solids, liquids, and gases
13. Electric bell, telephone, telegraph
14. Ventilation, principle of and different systems
15. Combustion

VIII. Seven of the 14 Text-books

1. Siphon
2. Human ear, parts and functions of each
3. Weathering
4. Fertilization
5. Lenses, kinds
6. Day and night, cause

7. Capillarity
8. Gasoline engines
9. Plant nutrition

IX. Six of the 14 Text-books

1. Metric system
2. Density and specific gravity
3. Archimedes' principle
4. Survey of animal kingdom
5. Time, standard, etc.
6. Electrolysis
7. Fuels and carbon compounds

X. Five of the 14 Text-books

1. Human body, structure of
2. Energy: Kinds, measures for
3. Life processes in animals
4. Pasteurization
5. Properties of protoplasm
6. Mechanics of respiration
7. Pollination and fertilization in plants

XI. Four of the 14 Text-books

1. Seed dispersal
2. Glaciers
3. Latitude and longitude
4. Cohesion and adhesion
5. Wind power
6. Human voice
7. Earthquakes and volcanoes
8. Parasites and saprophytes
9. River development
10. Economic botany

XII. Three of the 14 Text-books

1. Analysis and synthesis
2. Boyle's law
3. Hydraulic press

OUTLINE OF STANDARDIZED COURSE BASED ON TEXT-BOOKS (WECKEL STUDY)

I. Atmosphere

1. Physical properties and mechanics of gases
2. Chemical composition
   (*a*) Elements, compounds, mixtures
   (*b*) Molecular theory of matter
   (*c*) Study of oxygen, nitrogen, carbon dioxide
   (*d*) Oxidation
3. Atmospheric moisture
   (*a*) Evaporation
   (*b*) Humidity
4. Weather
   (*a*) Air pressure
   (*b*) Pumps
   (*c*) Barometer
   (*d*) Temperature
   (*e*) Winds
   (*f*) Storms
5. Respiration in plants and animals[1]
   (*a*) Hygiene of breathing
   (*b*) Ventilation

II. Water

1. Physical properties
2. Chemical composition
   (*a*) Solution
   (*b*) Hard and soft water
3. Mechanics of liquids
4. Distillation
5. Evaporation
   (*a*) Refrigeration
   (*b*) Manufacture of artificial ice
6. Water supply
   (*a*) Source
   (*b*) Purification
7. Sewage disposal
8. House piping
9. Hot water heating[2]

[1] Frequently included under IV.

[2] Frequently included under VI.

III. Earth

1. Its relation to the universe
   (*a*) Stars and solar system
   (*b*) Earth and its seasons
2. Soil
   (*a*) Origin
   (*b*) Physical structure
   (*c*) Erosion and sedimentation
   (*d*) Fertility
   (*e*) Soil water
   (*f*) Drainage
   (*g*) Irrigation

IV. Life on Earth

1. Plants
   (*a*) Cell, structure and activities
   (*b*) Parts of plants and their functions
   (*c*) Food production
   (*d*) Food storage
   (*e*) Reproduction
2. Animals
   (*a*) Groups
   (*b*) Human physiology (often omitted)
   (*c*) Reproduction
   (*d*) Insects and diseases
3. Bacteria, yeasts, and molds
   (*a*) Human diseases
4. Hygiene and sanitation

V. Foods and Nutrition

1. Foods
   (*a*) Need of
   (*b*) Production
   (*c*) Measurement of food—calorie
   (*d*) Composition
2. Digestion
   (*a*) Organs of
   (*b*) Hygiene
3. Diet
4. Adulteration

VI. Machines, Work, and Energy

1. Work of running water—water wheel, turbine, etc.
2. Work of simple machines
3. Measurements and kinds of energy
4. Heat
   - (*a*) Transmission of
   - (*b*) Fireless cookers
   - (*c*) Methods of heating our homes
   - (*d*) Coal
   - (*e*) Work done by heat—steam engine
5. Light
   - (*a*) Nature
   - (*b*) Color
   - (*c*) Human eye
   - (*d*) Methods of lighting our homes
6. Sound
   - (*a*) Nature
   - (*b*) Human ear
7. Electricity and magnetism
   - (*a*) Measurement
   - (*b*) Electric generators
   - (*c*) Applications of electricity
     - (1) Electric bell
     - (2) Automobile
     - (3) Telephone
     - (4) Telegraph

STUDY NO. 18C

How to Meet Some of Children's Nature Interests

By E. Lawrence Palmer*

Problem.—To determine the nature interests of rural children as revealed by their questions.

* *The Nature Study Review* (Comstock Publishing Company), January–February, 1922. Vol. XVIII, pp. 23–30. This study is abstracted from an article containing much additional material.

Method.—A request was made on the last pages of *Cornell Rural School Leaflet* for September, 1921, that teachers should send in the nature-study questions which had been asked by the pupils. The findings were based upon the first 500 questions submitted, "though the more recently received questions show no indication of varying greatly in their nature from the first 500."

Findings.—(1) Eighty-six per cent of the questions asked dealt primarily with biology, 5.2 per cent with organic nature, 4.2 per cent with practical agriculture, 3.4 per cent with pedagogy, and 1.2 per cent with miscellaneous items.

2. Sixty-two and eight tenths per cent of the total number of questions asked, dealt with zoology. These were classified under the following headings: invertebrates, 25 per cent (of the total number of questions on all subjects); birds, 15 per cent; mammals, 12.2 per cent; reptiles, 5.4 per cent; Amphibia, 4.2 per cent; fish, 1 per cent.

3. Twenty-one and eight tenths per cent of the total number of questions dealt with botany. These were classified as follows: woody plants, 14 per cent (of the total number of questions on all subjects); herbs, 6 per cent; Fungi, 1.8 per cent. The total number of questions asked under botany did not equal the number asked concerning insects.

4. One and four tenths per cent of the total number of questions asked were of a strict ecological nature. "Many questions classified under zoology and botany might however with equal justice be considered under ecology."

5. "Trees seemed to be more interesting than herbs, though the fact that these questions were returned in the fall when the leaves were dropping from the trees may have been an influence here. In this connection, it might be mentioned that apparently the season at which the questions

were written had considerable to do with the nature of the questions."

6. Of the total questions, of which those on inorganic nature claimed 5.2 per cent, 2.6 per cent dealt with geology and paleontology; 2 per cent with meteorology; and 0.6 per cent with astronomy.

7. "Applied science in the form of agriculture laid claim to 4.2 per cent of the grand totals, the questions being divided more or less equally between gardening, dairy, farm crops, and poultry. The cow's cud seemed to be the basis for more questions in this group than any other thing."

8. The 3.4 per cent of the total number of questions dealing with teaching problems were obviously asked by the teacher rather than by pupils. "The chances are quite probable that many of the teachers wrote down only those questions which they themselves could not answer or which they considered unusual."

9. Thirty-nine and eight tenths per cent of all the questions asked dealt with habits and activities; 19 per cent with taxonomy; 16.6 per cent with economy; 8 per cent with teaching problems; 6.4 per cent with physiology; 5.2 per cent with miscellaneous subjects; 3.2 per cent dealt with ecology; 1.2 per cent with definitions; 1.2 per cent with morphology; and 0.6 per cent with legal questions.

10. The most frequently recurring type of question asked regarding invertebrates, birds, mammals, reptiles, Amphibia, and fish concerned their habits. "More questions concerning taxonomy were asked concerning herbs and Fungi than of any other sorts, and the greatest number of questions asked concerning these dealt with plant physiology. A very large number of the questions asked and grouped under habits and physiology might with equal justice be considered as being under the heading of ecology."

11. ". . . not one of the 500 questions dealt with exotic plants and animals having no everyday association with the lives of children."

12. "The most commonly asked question was, 'What is the difference between moths and butterflies?'"

13. "Absurd questions were . . . surprisingly few and everything pointed to the conclusion that the questions given were such as might have arisen from the inability to interpret observations which had been more or less deliberately made."

STUDY NO. 19C

Outline for Sex Education in the High School
By James E. Peabody,* (Chairman)

Problem.—To determine the basic aims of sex education and to prepare a syllabus for sex instruction.

Method.—A committee of six appointed by the New York Association of Biology Teachers prepared this outline after nearly three years of conference and discussion. This outline was unanimously approved by the Biology Association in the fall of 1921. The outline was then submitted to Dr. John J. Tigert, United States Commissioner of Education, who sent copies for criticism to 200 representative principals of secondary education in various states. Sixty-five replies were received; practically all those who wrote expressed heartiest approval of the aims, content, and methods recommended.

Findings.

* *School and Society*, June 10, 1922. Vol. XV, pp. 650–652.

REPORT OF COMMITTEE ON SEX EDUCATION, NEW YORK ASSOCIATION OF BIOLOGY TEACHERS

I. Aims of Sex Education.

A. To give the young a wholesome and appreciative attitude toward matters relating to sex.

B. To supply a proper vocabulary for the discussion of sex.

C. To answer the natural questions of children and youths in such a way as to prevent morbid and to give healthy attitudes toward sex matters.

D. To prepare girls for the experience of menstruation and boys for the experience of seminal emissions—a preparation made necessary since parental instruction in these matters is woefully lacking.

E. To strengthen the character of boys and girls against the common temptations of youth.

F. To reduce the tension and worry that are commonly associated with excessive or improperly motived repression.

G. To teach pupils, both by precept and example, to discriminate for themselves between the wholesome and the salacious, as presented by companions, by the stage, motion pictures, reading matter, dancing and other amusements; and to develop a taste and preference for the wholesome.

H. To give young men and women some conception of the responsibilities of parenthood in the light of modern science, and of the conditions under which happy married life may be had.

I. To train the present generation of boys and girls, so that they in turn may be prepared to do their part in giving suitable guidance in sex matters to their children.

II. Point of View of the Committee.

1. As a result of our experience in teaching adolescents, the committee is strong in its belief that there is great need of sound and sane sex education for all boys and girls.

2. We believe that while this subject is of the greatest importance, it it unwise to introduce definite sex instruction to any considerable extent in a given community, if there is marked opposition on the part of the educational authorities.

3. We recognize that the particular province of this committee is with the students of the high school period and to that period we have confined our attention even though we believe the

subject should be presented to boys and girls much earlier in life.

4. The committee cannot stress the fact too strongly that success in this work will be contingent upon its presentation by teachers especially fitted by training, character, and good judgment.
5. While we do not desire to present a formal program, we are confident that all instruction bearing on sex hygiene must be co-ordinated with moral and ethical aims, since character rather than mere information, is the real goal and aim of sex education. Therefore all presentation of structure and function must be subordinated to these aims.
6. We believe that only a minimum amount of instruction concerning pathological conditions should be given, and then only to safeguard the individual student and the community. For this reason, we feel that, in general, physicians and nurses should not present this subject to high school classes, both because of the undue emphasis they would be likely to place on anatomical and pathological facts, and because of their lack of pedagogical training.
7. It is obvious that girls and boys should be segregated when direct biological sex instruction is given, and should in each case be taught by an instructor of the same sex.
8. While it is evident that certain phases of sex education are naturally based upon and most easily taught in connection with sciences having a biological content, we consider it inadvisable to limit sex education to the biological field, or to present it as a separate and isolated course in the curriculum. Physical training, home nursing, literature, the social sciences and domestic science, for instance, may be made most valuable vehicles for sound sex instruction and guidance. The teacher of any subject who is sensitive to the mental and physical needs of adolescents undoubtedly can be a messenger of vital truths in this field.

SUGGESTED OUTLINE[1] FOR RATIONAL SEX EDUCATION FOR BOYS AND GIRLS DURING THE HIGH SCHOOL PERIOD

The work of the third and fourth years might be combined in a series of talks and discussions, occupying possibly three to five periods; the outline, however, might better form the basis for a much more extended course. In at least two of the New York high schools this sex instruction is given in connection with general hygiene in the senior year, one period a week for two terms. In this way it is both enriched and suitably co-ordinated.

A. First or Second Year Instruction.—Study of the process of reproduction in plant and animal life: Its relation to the stream of living organisms reaching back to the dawn of life on earth; its relation to the next generation

I. Asexual reproduction in plants and animals

II. Sexual reproduction in plants, animals, and man

1. Flowers and cross fertilization
2. Fertilization, reproduction, development and care of young in animals (e.g., Mollusca, insects, fishes, Amphibia, reptiles, birds, and mammals), and in man. In connection with this topic, develop briefly the principles of sacrifice and service in nature; e.g.,
   (*a*) The relation between the number of young and the structural and instinctive provisions for the protection and nurture of offspring in animals and man
   (*b*) The relation between the degree of development of each vertebrate class, the amount of nourishment furnished by mother, and the length of the period of protection
   (*c*) The principle demonstrated above; namely, that the reduction in the number of young which has taken place in organic evolution has been in a general way proportional to the increase in the nourishment and protection secured by the offspring from their parents
   (*d*) Effect of these facts and of the length of infancy upon character and relation of parents, and upon the possibilities of education

[1] All the topics in this outline are now actually being taught, in whole or in part, in several of the high schools of New York City, Philadelphia, Chicago, Cincinnati, and elsewhere.

3. **Variation and heredity**
   (*a*) Variation resulting from sexual reproduction
   (*b*) Characteristics of both parents transmitted through the sex cells
4. Discussion of the special problems of puberty at the discretion of the teacher
   (*a*) Suggested topics for boys' classes, see **B, IV,** 4
   (*b*) Suggested topics for girls' classes, see **B, IV,** 4a

III. Factors necessary for a high degree of human development

1. Before birth
   (*a*) Proper nourishment
   (*b*) Needed protection
   (*c*) Good inheritance
   (*d*) Health and normal parenthood free from venereal infection
2. After birth
   (*a*) Home
   (*b*) Food
   (*c*) Clothing
   (*d*) Language
   (*e*) Opportunity for play and physical and moral development
   (*f*) The spirit of the family
   (*g*) Social customs
   (*h*) Moral habits
   (*i*) Vocations and avocations

IV. The home, a product of the family group

1. The home, a natural unit, should be based upon a spiritual love, which is in sharp contrast to the mating instincts of lower animals. The former is a spiritual love which endures through a life time, while the latter is promiscuous and of short duration
2. The rewards of cultivated talents and a social spirit
3. The penalties and consequences of perverted instincts

B. Third Year Instruction—Evolution and Eugenics

I. Laws of heredity

II. General facts of evolution, with typical examples

III. Inheritance as applied to man; eugenics; selection of mates

IV. Special information about problems of sex calculated to aid young people, if wisely interpreted and applied

1. Ovary, spermary, ovum, and sperm cells; structure and functions
2. Elementary mammalian embryology with some anatomy; ovulation, internal fertilization, placentation, and typical embryo stages (To be correlated with **A, II,** 2, a)
3. Internal secretions, and their coordinating function in development
4. For boys: Special problems of adolescence; the cultivation of attitudes; the exercise of self-control; mental hygiene; chivalry and fairness; seminal emissions and masturbation in relation to health; possible consequences; relation of personal happiness to social welfare

4a. For girls: Special problems of adolescence; normal womanly development and aspiration; the exercise of self-control; menstruation—its significance and hygiene

5. Venereal diseases in connection with a study of communicable diseases and prostitution

V. Sex standards and morality

1. Wholesome interest of boys and girls in each other; the doctrine of equality and the square deal
2. Morality, rather than sensuality, the dominating factor in social life; the single standard of responsibility for sex endowments, family life, and social progress
3. The germ plasm as a heritage in trust
4. The best social ideals as a social heritage in trust

C. Fourth Year Instruction—Suitable aims and ideals of human beings

I. Capacity for pleasure

1. The aspects which are largely physical, as in lower animals; eating, sleeping, warmth, resting, playing, dancing, and sex relations; all susceptible both of degradation or increase by refinement
2. The aspects which are largely mental; all susceptible of cultivation: Appreciation of music, nature, art, literature, theater, lectures, travel, games, love, altruism

II. The demand for physical, mental, and moral heath

1. Scope and meaning of "health," individual and social

2. Necessity of work for both body and mind
3. Need of recreation for both body and mind
4. Capacity for play and the need of retaining it by proper habits
5. Development of greater capacity for enjoyment of the higher pleasures, intellectual and esthetic; the duty and manner of development

III. Rewards in later life of high ideals in youth

1. Possibility of pleasure of a high and spiritual sort
2. Opportunities for social pleasures in later years
3. Opportunities for service to family and community
4. The lasting, unlimited quality of these satisfactions as compared with the transient character of the more gross indulgences

STUDY NO. 20C

Common Mistakes in Natural History,

By William Gould Vinal*

Problem.—To test the kind and extent of mistakes pertaining to natural history.

Method.—The investigator gave an examination to 281 members of 14 different classes ranging from the junior high school through college. The examination consisted of a large number of parts some of which follow: (1) The subjects were given "old sayings" to complete, as "_____ as a bee," and along with these space was provided in which to write an economic fact about each animal; (2) 18 graduate students were asked to name the color of the breast of a male robin placed in a paper bag in which a small hole was cut to show a small area of the breast; (3) the subjects were asked to answer various questions concerning buds, trees, etc., which they might be expected to know accurately;

* *The Nature Study Review* (Comstock Publishing Company), November and December, 1922. Vol. XVIII, pp. 329–342 and 371–385.

and (4) to detect and correct errors in statements involving common misconceptions of scientific knowledge, e.g., "Night air is 'unhealthy,'" "Mosquitoes bite"; (5) they were made to react to other statements and questions which involved superstitions; and (6) to others which contained various "catches," as correct terms used incorrectly, in a limited sense, etc.; (7) they were given a spelling list of nature terms; (8) they were asked to give reasons for natural phenomena and agricultural practice; and (9) to give definitions of terms.

Findings.—(1) "The results show . . . that people are most apt to remember an old saying which is an untruth (prosaic ignorance) than even one economic fact about an animal."

2. Old sayings "receive a great deal of encouragement in first grade readers and early grade literature." "These sayings pertain to our commonest animals."

3. "Hearsay, reading, and observation, are the three vehicles of information and if judged by present-day results the effectiveness diminishes in the order named, hearsay being far more potent in our present working conceptions than observation."

4. Results which, following each phase of the study, are given in elaborate detail by tables and quotations, along with correct answers and observations concerning the origin of the misconceptions, "indicate how little the average student thinks and how little most of them see"; also how ignorant practically all are about material such as was used in this investigation.

STUDY NO. 21C

Naive Questions and Science Teaching

By Thomas H. Briggs*

Problem.—"To consider the naive questions of adults when confronted with a novel situation, in the belief that they will throw some light on the causes of mental passivity or of independent industry." "It is desirable in planning economic instruction, to know what sorts of naive questions the human mind frames, and to consider if they fall into any sort of orderly category."

Method.—A unique back collar-button, a circular slide-rule, or a "Lock-Tite" tobacco pouch was presented to an acquaintance, a fellow teacher, or a graduate student of education, and the questions he asked or that he betrayed by his actions were noted. The investigation was continued over a period of about 10 years.

Findings.—(1) No detailed count was kept of the questions but a hierarchy of questions was revealed in which the frequency decreased in sharply descending curve from the first type of question to the last.

2. The causes of the questions, both as to number and kind were:

(*a*) "Mental alertness, a desire to know, the annoyance of being ignorant." "This attitude is in some individuals strong only in the field of their particular interests; in others it is general, resulting in a breadth of information and a closely related and consequent culture."

(*b*) A "perceived relation between the object of the experiment and oneself." "In rare instances the subject, being

* *School Science and Mathematics*, January, 1923. Vol. XXIII, pp. 34–40.

highly self-conscious, refused to express or reveal his naive questions, apparently fearful that he might betray some discreditable intellectual weakness." Perhaps this attitude, too, was the result of unhappy experiences as a pupil under an unsympathetic or caustic instructor. "Usually, however, if the subject perceived or could be made to perceive some relation between the phenomenon and himself, his questions were multiplied and he persisted in his enquiry to satisfactory answers." The "habit of persistence yoked with the habit of enquiry . . . is most apt to result if 'satisfiers' can be assured to naive questions from early years . . ."

(*c*) Interest in an active phenomenon. ". . . in the classroom, the interest should be stimulated whenever possible by exhibiting in action the object to be studied."

3. "In the hierarchy of questions, the simplest and by far the most frequent is: 'What is it?' or 'What is it for?' An answer explanatory of the function, like 'Tobacco pouch,' satisfies both questions, but it is astonishing to find that in many instances a technical name, meaningless to the layman, leaves him content." "The satisfaction doubtless lies in the comfort of knowing something that others about one know and in a sort of intellectual snobbery that permits gloating over the ignorant." "The satisfaction or the pride in the knowledge of mere names . . . is valuable in the science class only as the basis for building up interests in higher types." "The method natural to human learning: the formulation of a problem, an appreciation of its worth, and then an attempt at solution, is developed by the teacher who permits, encourages, and assures satisfying answers to all sorts of questions."

"The second question in the hierarchy, second lowest in frequency and highest in importance is, 'How does it work?'

or, 'How is it used?'" Answers to this type of question, "adequate for many, . . . are for all basic to advance learning."

"The third question, if interest persisted so far was, 'Can I work it?' often expressed by reaching for the object or moving some part. This type of question is prompted by the desire for the "satisfaction of the instincts for being a cause and for activity." "Of little value, except as causes, the instincts have manifested the means of arousing other interests, and leading on to higher mental activities. It is obvious that, so far as feasible, pupils should be permitted to touch, move, and 'monkey with' specimens, instruments, and machines."

"The question fourth in order is, 'What makes it work?' or, 'What is the principle involved?' Most of the subjects were satisfied before reaching this level. This fact indicates that "science had not been successful either in high school or in college with these superior adults in its attempt to inculcate the habit of demanding the principle involved." The probable reason for "this indifference lies partly in the emphasis on principle before the earlier questions in the hierarchy had been satisfied and partly in the failure to encourage naive questions by providing satisfactory answers to those questions raised, whether they were the ones anticipated and desired by the instructor or not."

The last and highest question in the hierarchy was, "What extensions of the principle are possible?" "This is the field of the inventor." The pupils "should recognize that this highest type of enquiry exists, and should be frequently considered. That they may have the satisfaction of success, situations should be prepared that lead to easy rediscovery of extensions of a principle."

STUDY NO. 22C

Present Status of Biology in Secondary Schools

By Oscar W. Richards*

Problem.—To study course content in high school biology in different parts of the United States, as the first step in the preparation of a pedagogical test to measure achievement in high school biology.

Method.—In 1921 the investigator sent a circular letter to superintendents in 53 cities having a population of one hundred thousand or more, requesting of each a copy of the course of study in biology and the names of text-books used in teaching biology in the school system. Forty-five per cent of the superintendents replied and to those not replying a second letter was sent, along with a list of all the text-books included in the first replies, to be checked and returned. Twenty per cent of the superintendents replied to the second letter, and a third letter brought responses from all but four of the rest. Letters were sent to 16 more cities reaching the 100,000 mark in the 1920 census. Ten replied to the first letter and no further letters were sent to the other six.

Replies, all told, were received from 59, or 86 per cent of the 69 cities. These replies varied from a letter giving only the names of the text-books to five outlines, one text-book, and two pamphlets from one city. About 35 per cent of the cities replied that the course was out of print. About 30 per cent sent only schedules, indicating that the greater proportion do not have printed courses or syllabi for biology classes.

* *The School Review*, February, 1923. Vol. XXXI, pp. 143–146.

Findings.—(1) Fifty-nine cities use 67 different textbooks and reference books.

2. The 46 actual courses and syllabi on biological subjects received from 17 schools were distributed as follows: Botany, 15; biology, 12; physiology, 7; zoology, 12.

3. Thirty-four cities sent enough data that a tabulation of courses given could be made. Twenty-eight of these cities give botany; 20, biology; 21, physiology; 19, zoology; and 12, general science, which was tabulated, as it contains varying amounts of biological material.

4. "The amount of time given to biological subjects summarized for 20 cities shows that four give botany one period a day each day in the week; three give biology one period daily; two physiology, one period daily; and one zoology, one period daily. The biological courses were given with the greatest variation in time: One city reported two recitation periods and one double laboratory period per week while another reported one recitation and two laboratory periods per week." The only thing standardized is the length of the period, 40 minutes. "The general tendency is to give the science courses five hours per week, divided into three recitation periods and two laboratory periods, the latter being consecutive. Nineteen cities give biological sciences seven periods; botany, six; biology, four; physiology, four; and zoology, five."

5. "Most school systems emphasize hygiene in their physiological courses from more or less the practical viewpoint." Twelve report work in practical hygiene. Personal hygiene is given in two, but whether the work is general hygiene, or whether some definite knowledge of sex is taught, is not specified. Only two report directed work toward a solution of the sex-hygiene problem.

6. "Evidently during the war the biological courses were discontinued in many schools for several cities stated that the course would not be given again until 1922 and 1923."

7. "It is impossible to interpret how much material is given in the different courses. In some schools the work follows the seasons and varies with the material accessible in the different years. Others follow a text very carefully and have a definite outline to be followed. Some of the syllabi are very short, giving only the main topics, as 'photosynthesis' or 'study of cat as representative of a vertebrate,' but the tendency is to give a great amount of specific detail . . . [even] page references to the text-book used. Nineteen are so detailed that obviously the teacher must select the parts to be used in a given term."

8. "Most of the courses follow somewhat zoology or animal biology, as given in many colleges, covering the different forms of life by studying representative forms and adding physiology, heredity, etc., as the occasion offers. Only 10 cities follow either the civic biology idea or the project method. Most of the courses are so divided that they give a term each to plant, animal, and human biology, or physiology, as the latter is more frequently called."

9. "The main fact brought out is that biology is not at all standardized and that it is taught in such a variety of ways that any given course could be evaluated only by a knowledge of the efficiency and training of the teacher together with the actual observation of the work given in the classroom."

STUDY NO. 23C

The Contents of the Chemistry Laboratory Course

By H. E. Brown*

Purpose.—To determine what the "average course" in the chemistry laboratory is, as given in the modern high school text-book.

Method.—Fourteen laboratory manuals, published during a period a little longer than the preceding 10 years and "claiming to be suitable in a high school course in chemistry," were selected for analysis. The title and subject-matter of each experiment in each text-book were recorded on a card; these cards were sorted and arranged into groups so that all the experiments treating of one topic were included in 1 group. There were 37 groups in all. Each card was then examined to determine how many of the manuals treated of each of the different topics.

Findings.—(1) Since 30 out of the 37 topics are on the average treated by 13 out of 14 text-books, "it seems therefore logical to conclude that 13 out of 14 texts or about 93 per cent represent the fundamentals of chemistry."

2. Each of the text-books on the average treats of each topic by giving 2.5 exercises, with a range from 1.1 exercises for topics 14 and 27, to 24.9 exercises for topic 22.

3. ". . . there is a very definite agreement and a uniform agreement of selection of subject matter of the authors of the modern chemistry laboratory manuals. Hence, it is quite possible to use this composite laboratory course in chemistry as a starting point for standardization."

* *General Science Quarterly*, March, 1923. Vol. VII, pp. 203–221.

TOPICS OF STANDARDIZED LABORATORY COURSE IN CHEMISTRY (BROWN STUDY)

1. Introductory laboratory practices not involving chemical knowledge, including setting up apparatus, balances, burettes, bending glass rods, capacity and Metric system, density
2. Physical and chemical properties and physical and chemical changes, including heating metals and qualitative weight change, compounds and mixtures, mixtures changed to compounds, separation of components
3. The study of water, including physical properties, chemical properties, boiling and freezing, filtration, distillation, electrolysis, solubility in water, distribution of water, impurities in water, hydrogen peroxide
4. Solutions and solubilities, including solids, liquids, and gases, concentration by titration, solubility and heat, diffusion, saturation and supersaturation
5. Water of crystallization, including deliquescence, efflorescence
6. Preparation and properties of oxygen
7. Per cent of oxygen in the air
8. The action of a metal (sodium) on water
9. Preparation and properties of hydrogen
10. Definite and multiple proportions, including burning hydrogen in oxygen, equivalent of magnesium, sodium, etc., weight of a liter of oxygen, atomic and molecular weights, volumetric composition of steam, making water, reduction of copper oxide by hydrogen, law of definite and multiple proportions. In this group are included those experiments that are treated primarily so as to bring out the laws of definite and multiple proportions, and not to make a quantitative determination of an atomic weight
11. Preparation and properties of chlorine, including bleaching
12. Preparation and properties of hydrochloric acid, including tests for a chloride
13. Acids, bases, and salts, including neutralization, double decomposition, acid anhydrides, hydroxides, salts ionization, replacement, hydrolysis, acid salts and double salts, methods of preparing salts, titration, valence by displacement, colored ions, activity series, naming of compounds
14. Preparation and properties of nitrogen
15. The oxides of nitrogen, including preparation and properties

16. Preparation and properties of nitric acid, including aqua regia, nitrates, nitrites
17. Preparation and properties of ammonia, including analysis of household ammonia, compounds of ammonium, sources of ammonia
18. The study of sulphur, including allotropic forms, preparation of allotropic forms, sulphur matches
19. Preparation and properties of hydrogen sulphide, including metallic sulphides
20. Preparation and properties of sulphur dioxide, including sulphurous acid, detection in foods
21. Preparation and properties of sulphuric acid, including tests for sulphates, action with organic matter
22. Preparation of substances and the study of elements and compounds, including properties of special substances, processes, such as cyanide process for gold. The substances most frequently treated are iron, aluminum, iodine, phosphorus, chromium, bromine, copper, lead, silver, and arsenic. Under this topic, too, is included a great number of such experiments as "The Study of Chromium," "The Study of Tin," "The Ferrous and Ferric Characteristics," "Nitrogen Compounds as Fertilizers," etc. This list constitutes 349 of the total of 1422 experiments, or nearly 25 per cent of the total, but may be recorded as the work which "acquaints the student better with chemistry but does not represent a part of the outline to develop the chemical theory," nor is it strictly qualitative
23. Building materials, including plaster of Paris, calcium sulphate, quicklime, slaked lime, mortar, cement
24. Photography, including blue prints, silver photography
25. The blowpipe and the flame and their uses, including the Bunsen burner, the candle flame, oxidation and reduction, kindling temperature, wire gauze and flames, colored fire, Davy safety lamps, Welsbach burner, flame tests, bead tests, borax bead tests, cobalt nitrate tests
26. Carbon, including wood charcoal, animal charcoal, graphite, coke, deodorization and decoloration, carbon a reducing agent, charcoal filters, allotropic forms, distribution, destructive distillation
27. Preparation and properties of carbon monoxide
28. Preparation and properties of carbon dioxide, including carbonic acid, respiration, chemical fire extinguishers, carbon dioxide in air and breath, oxidation, combustion

29. The hydrocarbon series, including methane, illuminating gas, acetylene, coal gas, ethylene, marsh gas, benzene, preparation of petroleum products, properties and by-products
30. Water softening, including hard waters, calcium oxide and hydroxide
31. Study of fabrics, dyeing, and removing of stains, including fibers, cleaning fabrics, acid colors, basic colors, mordants
32. Foods, including carbohydrates, protein, analysis of flour, analysis of milk, tests for food components, fats, vinegar, butter, oleomargarine, dyes in foods, per cent water in foods, nitrogenous foods, albumen, coagulation of milk, bread, sugar in vegetables
33. Preparation and properties of baking soda, washing soda, and baking powders, including the Solvay process, sodium carbonate, decomposition by heat, tests for carbonates, calcium carbonate, acid calcium carbonate, other baking powders
34. Preparation and properties and the study of organic compounds, including wood alcohol, fractional distillation, starches, sugars, fermentation, ethyl alcohol, acetic acid, aldehyde, ether, esters, glucose, glycerine, chloroform, iodoform, formaldehyde, colloids, preservatives, soap, miscellaneous
35. Qualitative separation, including the identification of salts, tests for metals and acid ions, separation of groups
36. Quantitative experiments, including copper in copper sulphate, atomic weight of tin, oxygen in potassium chlorate, formula of zinc chloride, analysis of a silver coin, composition of zinc oxide, equivalent of zinc, per cent of water of crystallization in ammonium chromate, percentage of iron in ferrous sulphate, percentage of chlorine in sodium chloride, atomic weight of sulphur, percentage of water in a hydrated salt, equivalent of aluminum, percentage of alcohol in a liquid
37. Unclassified miscellaneous, including action of hydrochloric acid upon oxides, electrical conductivity, Boyle's law and the barometer, heat, light, electricity, and their relation to chemical action, thermometers, the nascent state, insecticides

Table VII

Topics of "Standard Course in Chemistry," Average Number of Laboratory Manuals Treating Each Topic, Average Number of Exercises per Manual per Topic, and "Weight" (Brown Study)

Topic	Number of manuals treating this topic	Average number of exercises per manual	Weight
1. Introductory laboratory practices not involving chemical knowledge	9	2.0	1
2. Physical and chemical properties and physical and chemical changes	14	3.0	2
3. The study of water	14	2.7	2
4. Solutions and solubilities	12	2.8	2
5. Water of crystallization	12	2.5	2
6. Preparation and properties of oxygen	14	2.2	1
7. Per cent of oxygen in the air	13	1.2	1
8. The action of a metal (sodium) on water	6	1.6	1
9. Preparation and properties of hydrogen	14	2.0	1
10. Definite and multiple proportions	13	3.0	2
11. Preparation and properties of chlorine, including bleaching	14	2.2	1
12. Preparation and properties of hydrochloric acid	13	1.8	1
13. Acids, bases, and salts	14	6.4	3
14. Preparation and properties of nitrogen	11	1.1	1
15. The oxides of nitrogen	13	2.0	1
16. Preparation and properties of nitric acid	14	2.7	2
17. Preparation and properties of ammonia	14	2.1	1
18. The study of sulphur	13	1.9	1
19. Preparation and properties of hydrogen sulphide	14	1.5	1
20. Preparation and properties of sulphur dioxide	13	1.4	1
21. Preparation and properties of sulphuric acid	12	1.6	1
22. Preparation of substances and the study of elements and compounds	14	24.9	10
23. Building materials	4	2.0	1
24. Photography	6	1.6	1
25. The blowpipe and the flame and their uses	13	4.0	2
26. Carbon	14	2.1	1
27. Preparation and properties of carbon monoxide	9	1.1	1
28. Preparation and properties of carbon dioxide	14	2.3	1
29. Hydrocarbon series	10	2.3	1
30. Water softening	9	1.2	1
31. Study of fabrics, dyeing, and removing of stains	10	2.2	1
32. Foods	12	3.2	2
33. Preparation and properties of baking soda, washing soda, and baking powders	11	2.8	2
34. Preparation and properties and the study of organic compounds	14	6.8	3
35. Qualitative separation	13	3.9	2
36. Quantitative experiments	10	2.5	1
37. Unclassified miscellaneous	9	1.5	1

STUDY NO. 24C

An Analysis of Current Examinations in High School Biology

By Stephen G. Rich*

Problem.—To determine what mental functions are actually involved in the study of high school biology.

Method.—A series each of examination papers of the College Entrance Examinations Board and of the Regents of New York State were selected for analysis, since "the working hypothesis is that the requirements of meeting these examinations serve as norms for the actual instruction, *even in courses that are not avowedly given for that purpose.*" The examinations tabulated were those of the Board from 1914 to 1921, inclusive, and those of the Regents from January, 1914 to June, 1922; alternate January and June examinations were taken until January, 1920, and all examinations thereafter were included.

In a preliminary study of some of the examination papers from these two sources, a "pedago-psychological" classification was determined. "The kinds of function involved in the answers to each question were determined from several sources: (1) The writer's introspective data; (2) the correct solutions as given in the 'cram-books' for both sets of examinations; (3) information by teachers of the subject; (4) information from pupils whom the writer had in 1921 perpared for these examinations; (5) chance remarks of the writer's pupils, noted during instruction.

Eleven groups of material were finally distinguished: (A) Rote memory for names; terms; names of animals, plants,

* *School Science and Mathematics*, March, 1923. Vol. XXIII, pp. 254–257.

and parts. (B) Rote memory for definitions. (C) Questions that involve *skill* in drawing. (D) Memory for morphological features. (E) Questions requiring thought. (F) Memory for processes, functions, and life-histories. (G) Rote memory for laws and principles. (H) Memory for laboratory procedure or experiments. (I) Memory for economic and harmful or useful effects and features of plants and animals. (J) Memory for substances contained in objects studied. (K) Questions other than those listed above."

"Each part of the question which could be counted separately for credit toward passing the examination was taken as a single question. The relative values given them in marking were disregarded. Each question as thus delimited was entered under *each* group to which it belonged. Some questions were thus entered two and three times but not more than this."

Findings.—(1) "Inasmuch as the memory questions total 94 per cent or more for Board, for Regents, and for both together, and the observation questions total less than 44 per cent for these groups of examinations, it will be plain that there is considerable overlapping of the two. It will be familiar to every teacher of the subject that the bulk of these questions are actually answered by memory of either text-book diagrams, teacher's diagrams, or by means of verbal memory. The figures for verbal memory, over 75 per cent for each set of examinations, confirm this."

2. "Rote memory for a particular group of facts is the outcome that is at present sought for in instruction in college-entrance biology."

3. "Approximately ¾ of this may be purely verbal memory."

4. "The ability to apply this knowledge in problems involving thought is not today sought."

5. "Such items as can be remembered by means of observation are in the main also such as can be learned from the text without any observation at all."

6. "There has been no constant trend or change in the psychological requirements in biology despite the changes introduced in the subject-matter during the last eight years."

7. "The variation from year to year in psychological functions required is very great within certain limits. It is great enough within the limits of the different kinds of memory to make the Board and Regents' examinations entirely inconstant as measures of pupils' achievement in biology."

8. "As taught for college-entrance the only advantage that biology today possesses is that its subject-matter may have some utility. In other respects it is on a par with Latin, Greek, or French. In short, it fails utterly to possess any of the educational values claimed for science except in so far as the subject-matter may have usefulness."

9. Only 19.5 per cent at most of the subject-matter treated in the examinations has definite and undoubted usefulness. The percentage of the remainder that is useful is thus far only to be decided by subjective judgment. The investigator considers that another 10 per cent, making 29 per cent in all, is the probable maximum of this except for pre-medical and pre-dental students. For these, another 10 per cent, making 39 per cent in all, may be useful.

10. The great fundamental interpretive principles of biology are entirely omitted in college-entrance teaching of the subject.

STUDY NO. 25C

The Status of General Biology in High Schools of the North Central States

By W. C. Reusser *

Problem.—To determine (1) what are the important aims governing the course in general biology; and (2) what units and divisions of subject matter should receive most emphasis.

Method.—The investigator sent a questionary to 337 schools in 10 states of the North Central Association. The teachers of general biology were asked to rank in the order of their importance, (1) eight aims of general biology and (2) the following phases of subject matter: (a) Structure and function of organisms; (b) interrelation between organisms and groups of organisms; (c) adaptations of organisms to environment; (d) classification of organisms; (e) man's ability to control the habits and relationships of plants and animals to serve his own ends. Also the teachers were asked (1) to check the one of the following divisions which they considered most important: plant biology, animal biology, human biology; (2) and to indicate whether they would treat these divisions separately. Replies were returned from 63 per cent of the schools of which 58 per cent were teaching general biology.

Findings.—(1) The two most important aims according to the teachers replying were:

* *School Science and Mathematics*, March, 1923. Vol. XXIII, pp. 258–261. Only Parts II and III of this questionary study, bearing directly upon aims and curricular materials, are here summarized.

OBJECTIVES OF BIOLOGY (REUSSER STUDY)

A. To broaden the pupil's knowledge of his own body through the study of the structure and function of other animals and plants.

B. To make the pupil a good citizen through his knowledge of good food, good health, and good living habits.

The three aims next in importance and of nearly equal value according to the replies were:

C. To train pupils to make accurate observations.

D. To train pupils to think clearly and to form logical conclusions based on facts.

E. To develop interest in the life of the environment by giving first-hand information of plants and animals.

2. The method of laboratory procedure more commonly used than any other is that in which the teacher gives directions either in oral or written form, from material previously selected from various sources.

3. The phases of subject matter listed above which should receive most emphasis though all were practically equal in value, according to the teachers replying, were (a), (b), (c), (e).

4. Human biology was considered the most important division by 70 per cent of these teachers.

5. As to treatment of the main divisions of biology, namely, plant, animal, and human biology, a wider division of opinion was expressed. Forty-two per cent would treat them as separate units; 59 per cent would treat the divisions as an interrelated whole.

STUDY NO. 26C

A Report on Objectives of General Science Teaching

By Philipine Crecelius*

Problem.—To determine the objectives of general science.

Method.—A number of objectives which had been used in previous studies and some from current magazines and new text-books were embodied in a questionary sent to superintendents of city schools to be distributed among the teachers of general science. The teachers were requested to rank the objectives in the order of their importance, to mark with a cross (×) those which they considered unworthy of any rank, and to add any worthy objectives not included. The findings were based upon 78 of the 118 replies received (out of 250 copies sent out) from cities in 16 states.

Findings.

OBJECTIVES OF GENERAL SCIENCE (CRECELIUS STUDY)

A. To provide opportunity for acquaintance with such elementary laws of nature as are necessary for the health of the individual and the community.

B. To give children information about those appliances which science has developed and which are useful in making for greater comfort and convenience in the home and community.

C. To give children a full opportunity to indulge in the playful manipulation of toys, tools, machines, etc., in order that they may explore the world of reality as deeply and widely as possible.

D. To provide opportunity for acquaintance with the simpler applications of science in public utilities in order that the individual may more adequately fulfill the duties of citizenship.

* *School Science and Mathematics*, April, 1923. Vol. XXIII, pp. 313–319.

E. To provide opportunity for acquaintance with the elementary laws of nature which aid in understanding those citizenship problems which arise in connection with such topics as conservation of our natural resources, smoke elimination, etc.

F. To provide opportunity for the student to explore the fields of science for the purpose of educational and vocational guidance.

G. To give such training as will result in increasing respect for the work of recognized experts.

H. To correct common superstitions and ignorant practices.

I. To satisfy the natural interests in the things and forces of nature with which men are surrounded and with which they must deal; to give information, interesting purely for its own sake.

J. To develop system, order, neatness, and possibly other attributes to the end that they will function in the ordinary affairs of life.

K. To contribute such specific ideals, habits, and concepts as those of accuracy, persistence, open-mindedness, honesty, cause and effect, which are essential to the study of science.

L. To give to pupils a broad and genuine appreciation of what the development of science means in modern social, industrial, and national life.

M. To afford in some measure an opportunity to show the importance of scientific research and to stimulate the spirit of investigation and invention on the part of the student.

N. To make pupils able to read more intelligently and with greater interest, articles on science in magazines and scientific books of a popular character, and to read with greater understanding literature containing scientific allusions.

1. "Practically no additional objectives were added."

2. "It is interesting to note that *C*, *G*, and *N* appear in the × column with the greatest frequency."

3. "Summarizing these results we might broadly state the general science objectives to be these:

"First—The health of the individual and the community.

"Second—Citizenship through an understanding and an appreciation of natural laws and their scientific applications to civic problems.

"Third—Scientific methods for problem solving.

"Fourth—Educational and vocational guidance.

"Fifth—General interest and information."

4. "In comparing the above ranking with one given to these same objectives by Mr. Pieper's students [in the Summer Session of the University of Chicago] . . . the amount of agreement is striking. Six of the objectives . . . occupy the same place in both studies. The only great difference in opinion seems to be in the case of *C* which here appears thirteenth on the list and was ranked fifth by Mr Pieper's students."

5. "It is significant that the objective ranked first by a wide margin is the one which occupies the same position among the objectives of all secondary education as outlined in the *Cardinal Principles of Secondary Education*."[1]

6. "Exploration for educational and vocational guidance is thought worth while; the exploration for its own sake seems to find little favor."

7. "The disciplinary value of general science is not ranked first by anyone even though it is considered favorably."

8. The correction of common superstitions and ignorant practices, the interpretation of literature, the development of a spirit of investigation, and the appreciation of the work of experts did not receive much favor.

STUDY NO. 27C

The Present Content of Biology in Secondary Schools

By Oscar W. Richards*

Problem.—To determine what is an "average course" in biology, as shown by an analysis of text-books, for the

[1] Bureau of Education Bulletin, 1918, No. 35.

* *School Science and Mathematics*, May, 1923. Vol. XXIII, pp. 409-414.

purpose of preparing a pedagogical test to measure achievement in biology.

Method.—The 6 most widely used text-books and reference books of the 67 used in 59 cities[1] were selected for detailed analysis since they represented "the courses as reported by about 75 per cent of the replies received"; also, since they would be "still more indicative of the average course in biology" because "in many of the smaller schools the teachers tend to follow a text more closely . . ." The text-books analyzed were Bergen and Caldwell's *Practical Botany*, Hunter's *Civic Biology*, Hunter's *Essentials of Biology*, Linville and Kelly's *General Zoology*, Gruenberg's *Biology*, Peabody and Hunt's *Elementary Biology*.

The average number of words was chosen as the simplest and most accurate index of the relative importance of different topics. The average number of words per line from at least 10 pages was multiplied by the number of lines to find the average number of words per page; the average number of complete pages per chapter, leaving out space occupied by illustrations, was multiplied by the average number of words per page to obtain the estimated number of words per chapter. "Laboratory suggestions, classification outlines, and similar data were estimated separately."

The illustrations were counted in three groups: (1) pictures of men, reproductions of historical documents, or other illustrations having to do with the history of biology; (2) pictures such as half-tones or illustrations of a pictorial nature; (3) "sketches, sections, charts, and schematic dissections."

"All these data were placed on slips of paper . . . along with the book number, the chapter heading, and a very

[1] Study No. 22C.

brief sketch of the contents of the chapter—a slip for each chapter." The slips for Hunter's *Essentials of Biology*, chosen because they were the most representative of topics in the different books, were pinned to a long strip of cloth in their normal sequence. "The slips of the other books were placed in vertical columns under headings of slips in the first book." If there was no suitable heading for a given slip, another column was made for it. It was thought that dividing the chapters would cause more work than the slight increase in detail would seem to justify.

These data were tabulated to show: (1) the general analysis of the books; (2) the average biological course as shown by these books in order of importance as indicated by amount written on each; (3) the contribution of each book to the average; and (4) the number of cities using each text-book.

Findings.

TOPICS[1] IN BIOLOGY (RICHARDS STUDY)

1. Vertebrate animals, fish, birds, mammals, frogs, etc.
2. Insects, various orders
3. Forms of lower plants, Algae, Fungi, ferns, mosses
4. Improvement of environment, breeding, public health
5. Foods and dietetics, alcohol and drugs
6. Health and disease
7. Seeds and seedlings
8. Respiration and excretion
9. Classification
10. Nervous system and sense organs
11. Structure and work of stem
12. Metazoa in general; division of labor
13. Molluscs

[1] The topics are given in "about the order and importance that is given to the different subjects in the average high school course in the United States."

14. Plants in relation to human welfare
15. Flowers and their work
16. Blood and circulation
17. Digestion and absorption
18. Surroundings or environment
19. Roots and their work
20. Functions and structures of living things
21. Interrelations of plants and animals
22. Crayfish and its adaptation to its life
23. Worms and their adaptation to their life
24. Leaves and their work
25. Forests and their protection
26. Evolution
27. Protozoa—Paramoecium and Amoeba
28. Great men and the history of biology
29. Growth, development, chemical cycle, sex, etc.
30. Introductions. What is and why study biology?
31. Parasitism
32. Fruits and their work
33. Man in general
34. Higher mental processes—habit, instinct, etc.
35. Human machine

1. "Since the lengths of the books are about the same, the time of publication had no effect on the amount of material as judged by the number of words written."

2. Gruenberg's *Biology* (1919), the most recently published of these books, has three times as many chapter headings as any of the other five text-books, and fewer illustrations than three others.

3. "There is more general biology taught than is indicated because of the interlocking of the topics."

4. There is a large variety in the separate courses as shown by the different text-books making up the average.

5. "The two Hunter text-books and Gruenberg's text represent the average course. They treat almost all of the

different topics in the table and follow somewhat the same relative sequence as is given in the average."

6. "Had the data been taken from the first 25 texts (instead of the first 6), excluding the laboratory manuals, the topic headings would have remained much the same and the sequence would not have changed to any considerable extent."

STUDY NO. 28C

An Analysis of the College Entrance Board Examinations in Physics

By Earl R. Glenn* and Ivan L. Brookmeyer

Problem.—In an attempt to find the best selection of subject matter for a course in high-school physics, it is important to analyze the subject matter of the College Entrance Examinations Board questions, as one of the available opinions, "valuable not because of the high percentage of high school pupils taking these examinations, but because of the influence of these set examinations upon teachers, authors, and publishers of text-books."

Method.—This analysis included all the Old Plan College Entrance Board questions in physics from 1911 to 1922, and the Comprehensive Plan questions from 1916 to 1922. Each question was written on a card, then carefully analyzed to find what facts or laws of physics were required for a correct answer. "Each definition, law, or fact, physical phenomenon, formula, or experiment required in the correct answer was broken up into separate scientific items." "As a result of this analysis, the 15 questions commonly given on one examination were found to contain from 25 to 40

* *School Science and Mathematics*, May, 1923. Vol. 23, pp. 459–470.

distinct items from the commonly accepted outline of high-school physics." The reliability of the analysis was found to be accurate approximately within 3 points in 40, that is, "the variation in the number of topics found in a given examination by 2 different individuals was approximately 3 out of a total of 35 or 40 topics appearing in a given examination." "These errors were found to be due to the fact that one person used a slightly different classification from that of the other."

Findings.

TABLE VIII

DISTRIBUTION OF QUESTIONS AND PARTS OF QUESTIONS IN PHYSICS (GLENN AND BROOKMEYER STUDY)

	Old plan	Comprehensive plan
Division of physics		
Mechanics	134	88
Heat	78	56
Electricity	68	58
Sound	59	33
Light	70	52
Total	409	287
Kind of knowledge demanded		
Physical terms	45	30
Laws and facts	103	60
Physical phenomena	82	62
Problems	154	124
Experiments	25	11

Table IX

Topics Found in Old Plan College Entrance Examinations Board Questions in Physics, 1911–1922, and Number of Times Each Topic Appeared in Examination Questions (Glenn and Brookmeyer Study)

	Times
I. Distribution and Frequency of Subject Matter of Mechanics	
1. Definition of physical terms	
(*a*) Moment of force	3
(*b*) Mass	2
(*c*) Density	2
(*d*) Weight	2
(*e*) Momentum	2
(*f*) Acceleration	2
(*g*) Specific gravity	1
(*h*) Work	1
(*i*) Power	1
(*j*) Unit of force	1
2. Laws or facts to be stated or used	
(*a*) Work equals force times distance	7
(*b*) Archimedes' principle	6
(*c*) Principle of moments	6
(*d*) One horse power equals 550 ft. lbs. per sec	5
(*e*) Meaning of center of gravity	4
(*f*) Boyle's law	3
(*g*) Newton's laws of motion	3
(*h*) Component of force	2
(*i*) Pressure in liquids ($p = hd$)	2
(*j*) Parallelogram of forces	2
(*k*) Specific gravity	2
(*l*) Mechanical advantage of pulley system	2
(*m*) Conservation of energy	1
(*n*) Pascal's principle	1
(*o*) Miscellaneous items, six in all, each	1
3. Physical phenomena to be described or explained	
(*a*) Why does object change weight in going from equator to pole	2

TABLE IX (*Continued*)

	TIMES
(*b*) Diagram pulley system	2
(*c*) Description and use of hydrometer	1
(*d*) Why easier to roll a barrel up a long board into wagon than to lift it vertically	1
(*e*) Changes in energy when a ball is thrown vertically upward	1
(*f*) Why do "bad" eggs float	1
(*g*) Use of spring and beam balances in determining mass and weight	1
(*h*) Construction and operation of aneroid barometer	1
(*i*) Height of aeroplane determined by barometer	1
(*j*) Illustrations of Newton's laws of motion	1
(*k*) Effect of angle on tension when three forces acting at a point are in equilibrium	1
4. Problems	
(*a*) Efficiency equation	7
(*b*) Equation for moments	5
(*c*) Gas-law equation (all forms)	5
(*d*) $D = \frac{M}{V}$	4
(*e*) Resolution of force	3
(*f*) Work equals force times distance	3
(*g*) $F = Ahd$	3
(*h*) $S = \frac{1}{2}gt^2$ or $S = \frac{1}{2}at^2$	3
(*i*) $v = gt$ or $v = at$	2
(*j*) Work principle applied to windlass	2
(*k*) Specific gravity using Archimedes' principle	2
(*l*) Work principle applied to inclined plane	2
(*m*) Work principle applied to pulley system	2
(*n*) Three forces in equilibrium acting at a point	2
(*o*) K. E. $= \frac{Wv^2}{2g}$	1
(*p*) P. E. $= Wh$	1
(*q*) Distance equals velocity times time	1
5. Experiments to be described	
(*a*) Determination of coefficient of friction	1

TABLE IX (*Continued*)

	TIMES
(*b*) Experimental proof of Archimedes' principle	1
(*c*) Parallelogram of forces	1
(*d*) Boyle's law	1
II. Distribution and Frequency of Subject Matter of Heat	
1. Definitions of physical terms	
(*a*) Mechanical equivalent of heat	3
(*b*) Dew point	2
(*c*) Relative humidity	2
(*d*) Specific heat	2
(*e*) Conduction	1
(*f*) Convection	1
(*g*) Radiation	1
(*h*) Temperature vs. quantity of heat	1
(*i*) Temperature	1
(*j*) Heat of fusion	1
2. Laws or facts to be stated or used	
(*a*) Heat of fusion of ice	7
(*b*) Specific heat of metal	6
(*c*) Heat of vaporization of water	5
(*d*) Mechanical equivalent of heat	1
(*e*) Meaning of B. T. U	1
3. Physical phenomena or devices to be described or explained	
(*a*) Cooling effect of evaporation	3
(*b*) Construction and operation of ice plant	1
(*c*) Temperatures of clear and cloudy nights	1
(*d*) Condensation from breath on cold day	1
(*e*) Convection in chimney	1
(*f*) Why a pond does not freeze solid in winter	1
(*g*) Methods of transferring heat and examples of each	1
(*h*) Three systems of heating houses	1
4. Problems	
(*a*) Method of mixtures equation	7
(*b*) Coefficient of linear expansion equation	5

TABLE IX (*Continued*)

	Times
(*c*) Heat units = mass × change in temperature × specific heat	4
(*d*) Gas equations (all forms)	3
(*e*) Efficiency equation	2
(*f*) Mechanical equivalent of heat	1
(*g*) P. E. = Wh	1
(*h*) K. E. = $\frac{1}{2}mv^2$	1
5. Experiments to be described	
(*a*) Heat is a form of energy	2
(*b*) Low conductivity of water	1
(*c*) Determination of dew point	1
(*d*) Mechanical equivalent of heat	1
(*e*) Cooling curve	1
(*f*) Coefficient of expansion of gas	1
(*g*) Relative humidity	1
(*h*) Specific heat	1
III. Distribution and Frequency of Items of Subject Matter in Electricity	
1. Definition of physical terms	
None	
2. Laws or facts to be stated or used	
(*a*) 1 H. P. = 746 watts	1
(*b*) Right hand rule for direction of current	1
(*c*) Rules for direction and magnitude of induced current	1
(*d*) Meaning of kilowatt-hour	1
3. Physical phenomena or devices to be described or explained	
(*a*) Telephone transmitter	3
(*b*) Telephone receiver	3
(*c*) Construction and operation of transformer	2
(*d*) Long distance transmission of electricity	2
(*e*) Storage cell	1
(*f*) Electroplating	1
(*g*) Distribution of charge on insulated conductor	1
(*h*) Effect of a charged body on an electroscope near it	1

TABLE IX (*Continued*)

	TIMES
(*i*) Diagrams of cells in series and parallel	1
(*j*) Effect of breaking a magnet	1
(*k*) Diagram of house wiring for door bell	1
(*l*) Electromagnet vs. permanent magnet	1
(*m*) Electromagnet, construction and strength	1
(*n*) Corrections in reading of compass in navigation	1
4. Problems	
(*a*) Ohm's law (all forms)	11
(*b*) Watts = EI	5
(*c*) Joint resistance of parallel circuits	5
(*d*) Distribution of current in parallel circuits	4
(*e*) Efficiency equation	4
(*f*) H (calories) = $.24I^2Rt$	3
(*g*) Electrochemical equivalent of metal	3
(*h*) Joint resistance in series	3
(*i*) Transformer equation for e. m. f	1
(*j*) Relation between watts and candle-power	1
5. Experiments to be described	
(*a*) Testing distribution of charge on insulated conductor	1
(*b*) Ammeter-voltmeter method for resistance	1
(*c*) Induced current by moving wire in earth's magnetic field	1
(*d*) Sign of electrification on charged body	1
IV. Distribution and Frequency of Items of Subject Matter in Sound	
1. Definition of physical terms	
(*a*) Noise vs. musical sound	2
(*b*) Intensity	2
(*c*) Quality	2
(*d*) Pitch	2
2. Laws or facts to be stated or used	
(*a*) Velocity of sound at 0° C	9
(*b*) Velocity of sound changes 60 cm. per sec. per 1° C.	8
(*c*) Relation between number of beats and frequencies	3

TABLE IX (*Continued*)

	Times
(*d*) Variation of intensity of sound with distance	1
3. Physical phenomena or devices to be described or explained	
(*a*) Interference of sound	3
(*b*) Transmission of sound	3
(*c*) Echo	2
(*d*) Resonance	2
(*e*) Source of sound	1
4. Problems	
(*a*) Relation of distance, speed, and time	5
(*b*) $v = nl$	4
(*c*) Resonant length for closed pipe	2
(*d*) Formula for beats	2
5. Experiments to be described	
(*a*) Pitch of musical sound	3
(*b*) Wave-length of musical sound	1
(*c*) Velocity of sound in open air	1
(*d*) Width of lake using gun, stop watch, and thermometer	1
V. Distribution and Frequency of Items of Subject Matter in Light	
1. Definition of physical terms	
(*a*) Index of refraction	3
(*b*) Shadow vs. image	1
(*c*) Conjugate foci	1
2. Laws or facts to be stated or used	
(*a*) Speed of light	3
(*b*) Images formed by lenses	2
(*c*) Principle focus of mirror	1
3. Physical phenomena or devices to be described or explained	
(*a*) Solar spectrum	5
(*b*) Pin-hole camera	2
(*c*) Color of opaque objects	2
(*d*) Color of mixture of yellow and blue pigments	2

TABLE IX (*Continued*)

	TIMES
(*e*) Color of objects in various colors of light	2
(*f*) Continuous spectrum	1
(*g*) Bright line spectrum	1
(*h*) Color of transparent objects	1
(*i*) Explanation of refraction by wave theory	1
(*j*) Roemer's method	1
(*k*) Eye-glass or far-sighted eye	1
(*l*) Refraction at edge of pond	1
(*m*) Images of lenses of compound microscope	1
(*n*) Critical angle for water	1
(*o*) Matching colors in daylight and artificial light	1
(*p*) Wave theory explanation of spectrum	1
(*q*) Photometer	1
(*r*) Path of light through telescope	1
(*s*) Images in plane, convex, and concave mirrors	1
(*t*) Index of refraction for "red light" and "green light"	1
4. Problems	
(*a*) $\frac{1}{Do} + \frac{1}{Di} = \frac{1}{f}$	9
(*b*) $\frac{Lo}{Li} = \frac{Do}{Di}$	9
(*c*) Photometer proposition	5
(*d*) Index of refraction $= \frac{V_1}{V_2}$	2
(*e*) Radius of mirror $= 2f$	1
(*f*) Plane mirror diagram	1
(*g*) Magnifying power of telescope	1
(*h*) Law of inverse squares	1
5. Experiments to be described	
(*a*) Production of spectrum of luminous body	1
(*b*) Index of refraction for glass	1

Table X

Topics Found in Comprehensive Plan College Entrance Examinations Board Questions in Physics, 1916–1922, and Number of Times Each Topic Appeared in Examination Questions (Glenn and Brookmeyer Study)

	Times
I. Distribution and Frequency of Subject Matter of Mechanics	
1. Definition of physical terms	
(*a*) Mechanical advantage	2
(*b*) Work	2
(*c*) Potential energy	1
(*d*) Kinetic energy	1
(*e*) Coefficient of friction	1
(*f*) Horse power	1
(*g*) Efficiency of a machine	1
2. Laws or facts to be stated or used	
(*a*) Archimedes' principle	7
(*b*) 1 H. P. = 550 ft. lbs. per sec	2
(*c*) Meaning of center of gravity	2
(*d*) Principle of conservation of energy	1
(*e*) Weight of 1 cu. ft. of water	1
(*f*) Action of compression air-pump	1
(*g*) Height of mercury in barometer independent of diameter	1
(*h*) Meaning of frictional resistance	1
(*i*) Uniformly accelerated and uniformly retarded motion	1
(*j*) Newton's laws of motion	1
(*k*) Boyle's law	1
3. Physical phenomena to be described or explained	
(*a*) Drawing of pulley systems	2
(*b*) Transformation of energy in falling body	1
(*c*) Mercury barometer	1
(*d*) Lifting stone under water	1
(*e*) Surface tension	1
(*f*) Archimedes' principle in aeronautics	1
(*g*) Why a stone can be thrown further than a cork	1
(*h*) Illustrations of Newton's laws of motion	1
(*i*) Effect of angle on tension in ropes	1

TABLE X (*Continued*)

	TIMES
4. Problems	
(*a*) K. E. $= \frac{Mv^2}{2g}$	4
(*b*) $F = Ahd$ and $p = hd$	4
(*c*) $D = \frac{M}{V}$	4
(*d*) Efficiency formula	4
(*e*) $W = Fs$	3
(*f*) $F = \frac{mv}{tg}$	3
(*g*) Boyle's law	3
(*h*) Inclined plane, $Wh = Fl$	2
(*i*) Coefficient of friction $= \frac{\text{force of friction}}{\text{weight}}$	2
(*j*) $S = \frac{1}{2}at^2$ or $S = \frac{1}{2}gt^2$	2
(*k*) Power $= \frac{\text{Work}}{550 \text{ ft. lbs. per sec.}}$	2
(*l*) Equation for moments	2
(*m*) Distance = average velocity × time	2
(*n*) Three forces in equilibrium acting at a point	2
(*o*) P. E. $= Wh$	1
(*p*) $v = at$	1
(*q*) Equality of sums of parallel forces in opposite directions	1
(*r*) Work principle applied to capstan	1
(*s*) Work principle applied to jackscrew	1
(*t*) Acceleration $= \frac{\text{gain in velocity}}{\text{time}}$	1
(*u*) $F = ma$	1
(*v*) $v^2 = 2gS$	1
(*w*) Specific gravity $= \frac{\text{weight of body in air}}{\text{loss of weight in water}}$	1
5. Experiments to be described	
(*a*) U-tube method of measuring gas pressure	1
(*b*) Boyle's law experiment	1

TABLE X (*Continued*)

	Times
II. Distribution and Frequency of Subject Matter of Heat	
1. Definition of physical terms	
(*a*) Coefficient of expansion	2
(*b*) Mechanical equivalent of heat	2
(*c*) Unit quantity of heat	1
(*d*) Temperature	1
(*e*) Specific heat	1
(*f*) Heat of fusion	1
2. Laws or facts to be stated or used	
(*a*) Specific heat	7
(*b*) Latent heat of condensation and vaporization	5
(*c*) Latent heat of melting	2
(*d*) Mechanical equivalent of heat	1
(*e*) Transferring heat from steam in radiator to room	1
3. Physical phenomena to be described or explained	
(*a*) Cause of ice's melting in closed refrigerator	1
(*b*) Comparison of mercury and air thermometer	1
(*c*) Pans of water in greenhouse to prevent freezing	1
(*d*) Effect of sprinkling street on hot day	1
(*e*) Hot days more unpleasant in moist than dry climate	1
(*f*) Apparatus for distillation of water	1
(*g*) Reciprocating steam engine	1
(*h*) Four cycle gas engine, construction, operation, cooling system	1
(*i*) Example of cooling effect of evaporation	1
(*j*) Three systems for heating houses	1
4. Problems	
(*a*) Heat units = mass × change in temperature × specific heat	7
(*b*) Mixture equation	4
(*c*) Gas equations (all forms)	3
(*d*) P. E. = Mh	2
(*e*) Efficiency equation	1
(*f*) Relation of F. and C. temperatures	1
(*g*) Expansion of a solid = $kl(t_2 - t_1)$	1
5. Experiments to be described	
(*a*) Coefficient of expansion	2
(*b*) Latent heat of vaporization	1

TABLE X (*Continued*)

	TIMES
III. Distribution and Frequency of Subject Matter of Electricity	
1. Definition of physical terms	
None	
2. Laws or facts to be stated or used	
(*a*) Meaning of kilowatt-hour	2
(*b*) Name of discoverer of induced currents	1
(*c*) Lenz's law	1
(*d*) Heat losses in transmission of electricity	1
3. Physical phenomena or devices to be described or explained	
(*a*) Telephone receiver	2
(*b*) Galvanometer or ammeter	1
(*c*) Commercial transformer	1
(*d*) Long distance transmission of electricity	1
(*e*) Leaf electroscope	1
(*f*) Charging electroscope by induction	1
(*g*) Use of electroscope in detecting positive charge	1
(*h*) Electricity produced by chemical action	1
(*i*) Two machines depending on induction	1
(*j*) Relative importance of two methods of producing currents	1
(*k*) Type of cell for ringing bells	1
(*l*) Local action in voltaic cell	1
(*m*) Polarization of cells	1
(*n*) Use of ammeter	1
(*o*) Use of voltmeter	1
(*p*) Electric bell	1
(*q*) Telegraph key and sounder	1
(*r*) Alternating current generator	1
(*s*) Transformation of energy in generator	1
(*t*) Drawing of electric circuit	1
(*u*) Telephone transmitter	1
4. Problems	
(*a*) Watts = EI	8
(*b*) Ohm's law (all forms)	7
(*c*) Distribution of current in parallel and series circuits	5

TABLE X (*Continued*)

	TIMES
(*d*) Resistance in series and parallel	4
(*e*) H (calories) = $.24I^2Rt$	2
(*f*) Voltage formula for transformer	1
(*g*) Watts = I^2R	1
(*h*) Efficiency equation	1
5. Experiments to be described	
(*a*) Determination of resistance of wire	1
(*b*) Volt-ammeter method of measuring resistance	1
IV. Distribution and Frequency of Subject Matter of Sound	
1. Definition of physical terms	
(*a*) Pitch	1
(*b*) Quality	1
(*c*) Frequency	1
(*d*) Resonance	1
(*e*) Forced vibrations	1
2. Laws or facts to be stated or used	
(*a*) Frequency and pitch	3
(*b*) Laws of vibrating strings	1
(*c*) Compare speeds of light and sound	1
(*d*) Amplitude of vibration and loudness	1
(*e*) Velocity of sound at o°C	1
(*f*) Effect of temperature on velocity	1
(*g*) Characteristics of musical sounds	1
3. Physical phenomena or devices to be described or explained	
(*a*) Echo	2
(*b*) Noise vs. musical sound	1
(*c*) Compare notes by violin and cornet	1
(*d*) Formation of beats	1
(*e*) Resonance	1
4. Problems	
(*a*) $v = nl$	3
(*b*) Formula for beats	2
(*c*) Closed organ pipe = $\frac{1}{4}l$	2
(*d*) Open organ pipe = $\frac{1}{2}l$	2
(*e*) Laws of vibrating strings	1

TABLE X (*Continued*)

	TIMES
5. Experiments to be described	
(*a*) Rate of vibration of sounding body	1
(*b*) Determining velocity of sound in air	1
(*c*) Relation between pitch and frequency	1
V. Distribution and Frequency of Subject Matter of Light	
1. Definition of physical terms	
(*a*) Index of refraction	3
(*b*) Candle power	1
(*c*) Spectrum	1
(*d*) Principal focus	1
(*e*) Conjugate foci	1
(*f*) Refraction	1
(*g*) Critical angle	1
(*h*) Reflection	1
(*i*) Dispersion	1
2. Laws or facts to be stated or used	
(*a*) Images formed by concave mirror	2
(*b*) Images formed by plane mirror	2
(*c*) Index of refraction	1
(*d*) Explanation of refraction	1
(*e*) Explanation of dispersion	1
(*f*) Images formed by convex mirror	1
(*g*) Compare images formed by thick and thin lenses	1
(*h*) Images formed by lenses	1
(*i*) Compare index of refraction for "red light" and for "green light"	1
3. Physical phenomena or devices to be described or explained	
(*a*) Formation of spectrum	3
(*b*) Drawing of images in concave mirrors	1
(*c*) Drawing of path of light through water and glass obliquely and perpendicularly	1
(*d*) Meaning of Fraunhofer lines	1
(*e*) Colored objects in colored lights	1
(*f*) Shadows cast by arc lamp and gas jet	1
(*g*) Drawing of path of light obliquely from air into water	1

TABLE X (*Continued*)

	TIMES
(*h*) Color of colored objects in natural and artificial lights	1
(*i*) Drawing of images in microscope	1
(*j*) Drawing of images in telescope	1
(*k*) Physical difference between "red light" and "blue light"	1
(*l*) Drawing of lenses and images in stereopticon	1
4. Problems	
(*a*) Law of inverse squares	4
(*b*) Bunsen photometer proportion	4
(*c*) $\frac{1}{Do} + \frac{1}{Di} = \frac{1}{f}$	4
(*d*) $\frac{Lo}{Li} = \frac{Do}{Di}$	4
(*e*) Time of exposure and intensity of illumination	2
(*f*) Use of similar triangles in image diagrams	1
5. Experiments to be described	
(*a*) Measuring intensity of light	1

STUDY NO. 29C

THE TECHNIQUE AND VALUE OF PROJECT TEACHING IN GENERAL SCIENCE

BY RALPH KNUPP WATKINS*

Problem.—To determine what are the chief current aims for the teaching of general science.

Method.—The investigator reviewed all the material in *School Science and Mathematics* from January 1, 1910, to December 1, 1921, and in the *General Science Quarterly* from November, 1916, to March, 1922. He also considered

* Doctor's thesis. *General Science Quarterly*, May and November, 1923, and January, 1924. Vol. VII, pp. 235–256, and Vol. VIII, pp. 311–341 and 387–422. Only the portion of this thesis which relates to the determination of aims is here summarized.

material from books on the teaching of science, scattered references to other periodical material found in bibliographies of general science, and the statements of aims found in the prefaces to all available text-books of general science. The aims, which were abstracted from 45 different references, were fitted into appropriate categories, the list of which was extended as need arose during the investigation. The principal aims found in this investigation were compared with those found in four important previous investigations.[1,2,3,4]

Findings.—(1) The most important aims of general science here determined were practically identical with those obtained by the four previous investigators. The "chief current aims" of general science teaching, both from the point of view of educational writers and of the teachers carrying on the work, are:

OBJECTIVES OF GENERAL SCIENCE (WATKINS STUDY)

To insure that the pupil acquires
A. An understanding and control of environment;
B. A fund of information concerning nature and science;
C. A preparation for later science courses.

Other important aims given in the order of frequency of appearance as found by the experimenter are:

[1] C. M. Howe, "Can and Should General Science be Standardized," *School Science and Mathematics*, XIX, 248–255.

[2] A. A. Worun, "General Science in Michigan," *General Science Quarterly*, II, 267–284.

[3] W. F. Roecker, "An Elementary Course in General Science," *School Science and Mathematics*, XIV, 755–758.

[4] C. F. Miller, "Survey of the General Science Situation in Illinois," *School Science and Mathematics*, XIX, 398–406.

To insure that the pupil acquires
D. A training in the scientific method;
E. A development of power of interpretation and appreciation;
F. A development of interest in science;
G. Culture.

STUDY NO. 30C

The Report of the Committee on a One-year Fundamental Course of Biological Science

By George William Hunter* (Chairman)

Problem.—To construct a one-year fundamental course in biology.

Method.—This committee was appointed at the conference meeting at the University of Illinois in 1921, to take up the work of a former committee ended by the death of its chairman, Professor Pricer. This committee found "itself in concurrence with" the seven objectives of the Committee of the Reoganization of Science[1] (Health, Command of the Fundamental Processes, Worthy Home Membership, Citizenship, Worthy Use of Leisure, Vocation, Ethical Character), and also "in entire sympathy with" the objectives of Dr. Hollister's committee (Health, Wealth, Association, Beauty).

"The 98 topics below were submitted in tabular form arranged so that the teacher could check the subject (biology, botany, zoology, physiology, general science, or agriculture) in which the topic was treated, and also so that they could indicate the year of the high school in which the subject

* *School Science and Mathematics*, October, 1923. Vol. XXIII, pp. 656–664. Only such portions of this report as bear directly upon course materials are here briefly summarized.

[1] *Reorganization of Science in Secondary Schools*, Bulletin No. 26, 1920. Bureau of Education.

matter was given and whether it was required as a part of the program of studies. One hundred fifteen schools replied giving material usable in whole or in part; 103 gave replies which could be used in their entirety.

The committee also considered the replies from a former questionary study made by one of the committee, indicating the reactions of 2500 first-year high school pupils in biological subject matter, who stated what biological material they considered most worth while.

"The committee has used all available data in making out the topical list that follows and believes it has named most of the fundamentals of a foundation course in biological science."

Findings.—(1) Over 90 per cent of the schools gave 84 out of the 98 topics.

2. "Only three topics, which fell considerably below the others, were omitted from more than 33 per cent of the schools."

3. "Only two topics were given by all, 'The cell as a unit,' and 'Flowers in relation to pollination.'"

TABLE XI

THE 98 BIOLOGICAL TOPICS WITH NUMBER OF SCHOOLS IN WHICH EACH TOPIC WAS TAUGHT AS A PART OF VARIOUS COURSES IN SCIENCE INDICATED[1] (HUNTER REPORT)

Topic	Tot.	Bi.	Bt.	Zo.	Py.	G. S.	Ag.
I. Living things in relation to their environment							
1. Factors in environment of living things[2]	108	35	66	59	30	33	18
2. Relation of plants and animals to factors of environment	111	34	66	61	20	35	14
3. General functions of living things	103	29	53	51	28	29	9
4. Ecological relationships; adaptations of living things	103	27	61	54	14	9	7
5. Man's relation to his environment	100	28	27	37	41	32	4
II. Interdependence of living things							
1. Shelter relation	94	29	40	47	20	31	9
2. Food relation	107	34	54	50	28	35	10
3. Balance between oxygen and carbon dioxide in green plants and animals	113	29	66	44	21	42	10
4. Symbiosis in its broadest sense	96	28	46	45	6	16	8
5. Parasitism and its result	108	30	66	62	16	19	8
III. Life processes in plants and animals							
1. Division of labor	105	31	52	58	32	18	4
2. Comparison of living and non-living things	107	33	51	50	24	41	4
3. Chemical composition of living things	99	27	48	37	36	33	10
4. Cell as a unit	115	32	68	57	41	40	6
5. Properties of protoplasm	109	32	59	57	39	28	4
6. Importance of chromosomes	90	26	43	44	18	8	6
IV. Green plants as living organisms							
1. Nutrition: Chemical and physical principles involved	110	32	61	14	19	29	13
2. Relation of raw material	101	29	58	8	6	39	11
3. The root as an absorbing organ	112	34	72	3	1	38	13
4. The organs of use in food making	105	32	70	3	6	39	4
5. Manufacture of food	110	31	68	2	8	42	13
6. Food stuffs and their tests	108	28	59	3	26	43	7

[1] These abbreviations stand respectively for Total, Biology, Botany, Zoology, Physiology, General Science, Agriculture.

[2] The items of this table would be worded as follows: "Factors in environment of living things" was taught in 108 of the 115 schools reporting, in 35 of which the topic was taught in biology; in 66, in botany; in 59, in zoology; in 30, in physiology; in 33, in general science; and in 18, in agriculture. It is obvious that there is overlapping—that the topics are touched upon in more than one of the courses.

TABLE XI (*Continued*)

Topic	Tot.	Bi.	Bt.	Zo.	Py.	G. S.	Ag.
IV. Green plants as living organisms, continued.							
7. Enzymes and their functions	108	31	58	12	27	29	10
8. Absorption and transportation of foods	112	31	74	14	18	16	12
9. By-products of starch making	100	29	62	0	5	29	8
10. Food storage: Its importance to man	113	31	71	6	14	38	11
11. Respiration	112	31	73	15	9	38	12
12. Transpiration	111	31	73	8	6	34	11
13. Oxidation as a means of liberation of energy	110	33	65	17	20	38	12
14. Excretion	111	32	63	22	23	28	12
V. Animals as living organisms							
1. Nutrition, sources of food for animals	109	29	12	57	33	30	19
2. Foods, functions of	108	27	13	45	46	39	16
3. Personal dietaries in relation to growth and maintenance	92	22	0	11	28	27	7
4. Hygiene of feeding	94	20	1	13	42	27	9
5. Economy in purchase and preparation	85	17	2	6	37	30	11
(*a*) Food adulteration	84	18	2	3	41	26	9
(*b*) Food and drug act	78	15	1	4	40	26	2
6. Organs of digestion	108	24	7	56	36	23	9
(*a*) In Hydra	92	23	4	56	7	6	0
(*b*) In Arthropoda	96	23	5	56	10	7	0
(*c*) In man	111	26	6	40	48	31	2
7. Enzymes and glands	108	23	5	46	50	29	10
8. Absorption and circulation	112	25	8	50	51	30	12
9. Blood making	108	21	2	34	47	22	6
10. Cell nutrition	98	23	12	46	49	24	3
11. Blood serum and serum therapy	74	18	2	11	30	17	7
12. Organs of respiration	111	27	17	60	53	33	9
13. Necessity of respiration	109	25	8	54	51	36	8
14. Assimilation	105	24	1	26	50	32	6
15. Excretion	107	27	7	48	51	27	13
16. Hygiene of respiration	107	26	6	55	49	22	9
17. Skeleton, muscles and motion	108	26	4	54	52	21	5
VI. Responses of plants and animals							
1. Simple responses to external stimuli	101	30	47	56	35	22	4
2. Body control and habit formation in man	108	26	3	15	57	17	2
3. Apparatus; simple structure of nervous system	101	23	3	36	54	14	1
4. Reflexes; habits and habit formation	93	24	5	28	54	16	0
5. Hygiene of sense organs	88	20	2	10	55	20	0
VII. Reproduction in plants and animals							
1. Reproduction in one cell plants and animals	113	31	70	62	23	28	8
2. Flowers in relation to pollination	115	32	76	12	3	35	12

TABLE XI (*Continued*)

Topic	Tot.	Bi.	Bt.	Zo.	Py.	G. S.	Ag.
VII. Reproduction in plants and animals, continued.							
3. Flower and insects	114	31	75	40	2	33	12
4. Seed formation	114	32	76	2	2	31	15
5. Uses of fruits in reproduction	110	31	72	1	1	18	13
6. Seed distribution	114	31	74	3	0	25	15
7. Conditions necessary for growth of seed	112	31	74	0	0	26	18
8. Germ cells in relation to soma cells	73	19	30	12	5	6	6
9. Reproduction in animals; simple explanation	108	31	2	63	9	18	13
10. Metamorphosis	109	31	2	58	3	14	5
11. Life history of frog	104	30	3	64	3	11	3
12. Development of seed	110	34	67	7	0	23	13
13. Development of mammal	81	26	4	41	6	12	8
VIII. Evolution							
1. Classification of plants, simple	108	28	71	4	0	7	8
2. Classification of animals	101	27	5	63	3	8	7
3. Meaning of evolution	109	30	47	64	12	28	6
4. Evidence of evolution	105	28	44	65	8	15	5
5. Man's place in nature	102	28	14	52	20	16	2
IX. Man's control of his environment							
1. In relation to public health							
(*a*) Method of dispersal of bacteria and diseases caused by them	113	27	39	20	51	53	6
(*b*) Methods of destroying bacteria	113	26	38	17	51	49	6
(*c*) Protozoa in relation to disease	107	25	5	54	43	34	2
(*d*) Insects in relation to disease	111	27	5	60	40	45	8
(*e*) Other animals of direct or indirect importance in the generation of disease	103	23	3	45	40	30	6
(*f*) Methods of disease prevention by individual emphasized	106	24	11	19	51	44	2
(*g*) Municipal sanitation	109	24	10	12	53	49	4
(1) Public supplies, milk, water, food	105	22	9	14	53	51	9
(2) City department in connection with public health	91	18	4	8	48	38	3
(3) Museums, schools, baths, parks, markets, etc., in relation to public health and public welfare	77	18	7	9	45	30	3
2. In relation to material wealth							
(*a*) Forest in relation to soil, water, plant and animal resources	107	26	62	9	3	32	2

TABLE XI (*Continued*)

Topic	Tot.	Bi.	Bt.	Zo.	Py.	G. S.	Ag.
IX. Man's control of his environment, continued							
(*b*) Food-producing plants and animals in their relation to the wealth of the nation	104	24	59	33	1	27	14
(*c*) General biological relations existing between birds and insects	101	30	12	55	0	15	7
(*d*) Protection of birds	98	32	13	52	0	20	9
(*e*) Laws, literature, and governmental work in protecting forests, wild flowers, birds, fish, and other animals	90	26	49	41	0	22	10
3. In relation to improvement of plants and animals							
(*a*) Factors in plant and animal breeding	100	28	58	46	4	16	19
(1) Heredity	104	36	54	49	8	15	20
(2) Variation	103	28	62	46	13	12	18
(3) Selection	102	26	62	47	12	14	20
(4) Hybridizing	101	27	61	40	2	14	19
(5) Inheritance of unit characters	90	23	47	39	6	12	17
(*b*) Improvement of man through eugenics, sanitation, and personal hygiene	86	27	11	24	33	25	5
(*c*) Biographical studies of some great biologists who have contributed to human welfare	85	27	40	48	15	12	2

STUDY NO. 31C

BIOLOGY IN THE PUBLIC PRESS

BY CHARLES W. FINLEY,* AND OTIS W. CALDWELL

Problem.—To determine the types of biology now going to the public through the press.

Method.—The complete issues of 11 prominent newspapers for the entire month of June, 1921, and of three of the same and three other newspapers for the month of November, 1921, were selected as representatives of the following types: those having large circulation but rather

* New York: Lincoln School of Teachers College, 1923.

limited geographical distribution; those with large circulation and wide distribution; those with more limited circulation and narrow distribution; those published in large cities and in small cities. The 17 full months' issues gave a total of 492 different papers with a total estimated number of 13,796 pages.

In a *preliminary study* a careful reading of a number of papers of various types, some not included in the list analyzed, was made "in order to collect articles which might be regarded as requiring some biological information for a better understanding." This was done to determine the probable value of the study and to give a basis for a tentative judgment "regarding the kinds of articles which should be considered in the investigation." Only those articles in which the main emphasis was biological were included.

The papers to be analyzed were given a *first reading;* "a careful scanning was made of every page of every issue of all the papers selected, in order to locate the articles . . . based upon biological information." All these articles were clipped, dated, numbered, and mounted. The clippings for each day's issue of each newspaper were mounted on a single sheet of paper and all clippings for a month for each paper were placed together in a folder. The clippings were then given a more careful *second reading* and "consultations were held regarding articles about which there was a question as to whether they should be included." Only articles distinctly biological in nature were included; those "making brief biological references were omitted," as were crop reports, trade or commercial items, or advertising items of a biological nature.

"A tentative *classification* was prepared on specially designed blanks, upon which were recorded the name of the article, a serial number, its date, the number of linear inches

of space, the general topic under which it might perhaps later be classified and a brief phrase suggestive of the content." "In determining the length, the nearest whole number of inches was used." "During the work of making clippings, a tentative scheme of classification was constantly corrected as different types of information were discovered; the plan of classification therefore was not predetermined but developed and resulted from a detailed study of the articles themselves." "Many articles dealt with more than one of the main topics but each article was classified under the heading which was consistent with its chief emphasis."

Findings.—(1) The total number of biological articles was 3061; their length in inches was 25,506; their average length in inches was 8.3.

2. Twenty-eight hundred forty-five of the 3061 articles and 23,517 of the 25,506 inches were devoted to *health, animals, plants,* and *food,* and only 216 articles and 1989 inches were devoted to *organizations of producers, general nature, evolution,* and *fictitious stories.* There was not only a larger number of articles, a greater number of total inches, and a greater average length of article devoted chiefly to the first four main topics, but there was a wider range in the nature and comprehensiveness as well as a more serious and fundamental treatment. "If these papers are representative, it may be concluded that these are the biological topics most commonly presented in the public press throughout the country."

3. Several times, a day's issue of a newspaper contained only one biological article but every issue contained at least one such article. The articles were found in considerable numbers on practically all the main topics in all the papers.

TABLE XII

BIOLOGICAL TOPICS FROM NEWSPAPERS IN ORDER OF NUMBER OF ARTICLES DEVOTED TO EACH (CALDWELL AND FINLEY STUDY)

Topic	Number of articles
I. Health	897
1. Germ diseases	207
(*a*) Smallpox	90
(*b*) Tuberculosis	32
(*c*) Treatment	16
(*d*) Rabies	11
(*e*) Yellow fever	9
(*f*) Diphtheria	8
(*g*) Typhus and typhoid	7
(*h*) Bubonic plague	6
(*i*) Colds	6
(*j*) Malaria	5
(*k*) Sleeping sickness	3
(*l*) Influenza	3
(*m*) Leprosy	3
(*n*) Scarlet fever	2
(*o*) Lockjaw	2
(*p*) Infantile paralysis	1
(*q*) Pellagra	1
(*r*) Chicken pox	1
(*s*) Measles	1
2. Hygiene and sanitation	203
3. Health education	179
4. Non-germ diseases	119
5. Dietetics	65
6. Drugs	52
7. First aid	45
8. Physiology	27
II. Animals	755
1. Improvement and care	171
2. General interest	148
3. Recreation and enjoyment	99
4. Obnoxious	99
5. Economic importance	89
6. Conservation and propagation	44
7. Interrelations	38
8. Diseases	35
9. Life histories	17
10. Geographical distribution	11
III. Plants	660
1. In cultivation	201
2. Forestry	105
(*a*) Economic value	40
(*b*) Conservation and reforestation	33
(*c*) Forest fires	23
(*d*) Recreation value	9
3. Gardening and horticulture	91
4. Climatic influences	62
5. Breeding and improvement	59
6. In industries	54
7. General interest	25
8. Diseases	24
9. Memorial planting	16
10. New plants	13
11. Obnoxious	6
12. Conservation	4
IV. Food	533
1. Costs	150
2. Shipping and packing	105
3. Pure	77
4. Production of and national welfare	75
5. Aid in production	60
6. Conservation and preservation	51
7. Preparation	15
V. Organization of producers	81
1. Social and economic welfare	53
2. For improvement of product	28
VI. Nature	74
1. Education	52
2. Recreational value	18
3. Conservation	4
VII. Evolution	47
1. Man	23
2. Animals	16
3. Struggle for existence	7
4. Plants	1
VIII. Fictitious	14

4. The large number of articles pertaining to health provides supporting evidence that health is the most important

objective of modern education. There is, however, much variation in the number of articles in different papers.

5. The papers which are in the first eight in number of articles are also the first eight in quantity of material as shown by length.

6. By a study of the files of the *Kansas City Star* for the month during which the epidemic of small-pox occurred, "it is possible to plan a campaign for needed city ordinances and types of public information for use in such an emergency."

7. ". . . the whole question of biology, so far as the public press is concerned, is homocentric, as these articles either directly or indirectly relate themselves to biology as it affects man. This differs fundamentally from the organization of most of the text-books in elementary biology." "It is thought that introductory instruction in biology should recognize more fully the relation of the subject to man."

8. "If the number of articles found is indicative of public concern, people in the United States are giving much attention to the problem of producing better live stock."

9. "None of the papers failed to include articles dealing with the culture of plants."

10. "The public press emphasized the economic side of the food question."

11. "The recent publicity given evolution by protagonists and antagonists is but slightly reflected in the number of articles found concerning it."

12. "But few articles appeared which could be classified as fictitious, spurious, or pseudo-biology."

13. "The articles found cover topics of the same general types in all parts of the country with local variations usually explainable upon the basis of local occurrences of special

local interest." "Quantity in space and number of articles varies widely" in the different localities.

14. While differences of opinion regarding various topics were not infrequent, the gross misstatements of facts were not common. ". . . the reliability and high standard of material collected is one of the definite impressions made by the study."

15. "Newspapers appear to be more up-to-date in the things biological than are college and high school texts in the subject."

16. "The conclusion cannot be drawn that since these biological articles have been found, and since they are clearly grouped into certain definite headings that therefore these are necessarily the topics toward which all high school instruction in biology should be directed." But since these types of biological knowledge are going to the public in such large quantities, and over the whole country, they are thought surely to reflect genuine public needs and interests, and therefore, "the course in biology should consider them as part of the legitimate foundation upon which to proceed in constructing a course of study."

17. "Teachers should use many of these type articles, or others equally good, as cases or situations with which to begin discussions or study of classroom problems in biological instruction." "Constant employment of such specific types of public use of biology as are set forth in the newspapers studied would probably do much to advance the value of biological instruction."

STUDY NO. 32C

Children's Interests as a Basis of What to Teach in General Science

By C. A. Pollock *

Problem.—To ascertain some of the scientific questions of eighth grade children, for the purpose of guiding more intelligently the selection of text-books in general science and the choosing of a list of supplementary scientific readings.

Method.—The following form was put into the hands of every eighth-grade child in Columbus, Ohio:

Boys and Girls: You have by this time advanced far enough in the study of science to realize that in many ways it helps you to understand the things which you never understood before. As a wide-awake boy or girl you have been wondering about the rain, wind, and sun; about things living and things mechanical. Always there is present in your mind a question and somewhere in this new subject of science there is an answer.

Science takes in a great many things; and because there are so many, our great scientists usually spend their time on one special thing in which they are interested. Some scientists have found out for us much about the sun, moon, and stars. Some have spent their time learning about plants and flowers; others about birds, insects, and other animals. Some have performed wonderful experiments with chemicals. Other men are working with electricity, finding out for us about radio, the telephone, the telegraph, the electric light, and the street car. Some spend most of their time studying the winds, the clouds, the ocean, mountains, rocks, and minerals. In this vast storehouse of information are to be found solutions for the things that puzzle you. Now in order that the teachers of general science may be most helpful to you they desire to know what boys and girls of your age find most interesting. To determine this you are each asked to make a list of

* *Ohio State University Educational Research Bulletin*, January 9, 1924. Vol. III, No. 1, pp. 3–6.

no more than five things or questions in which you are really most interested. When you go home tonight spend some time thinking it over and then make your list at the numbers indicated below. Bring them back tomorrow to be collected and arranged in order.

Perhaps these examples will help you.

"Tom: What makes an automobile go?

"John: Are there people living on Mars?

"Mary: What makes the gas stove go pop?

"Ruth: How far away are the stars?

"Gene: What makes the leaves turn yellow?

"Bob: Why does the thunder make the windows rattle?"

The 3500 questions received from children in 13 schools were grouped under appropriate word headings.

Findings.—(1) One hundred nineteen interests were indicated by the answers.

2. No special interests were found in the 8-A (high) which were not found in the 8-B, and the interest span of pupils in the latter was found to be 7.7 per cent greater than that of pupils in the former.

3. "The range of interest with the girls was found to exceed that with the boys by 10 per cent."

4. While there was considerable overlapping, there were many interests of girls not expressed by boys and vice versa. "Hence in the science course as elsewhere provision should be made, as far as practicable, for sex differences."

5. Only 43 per cent of the interests questions were answered or touched upon by the author of the general science text-book used by these pupils.

6. "In an examination made of 15 text-books by Morris Meister of Teachers College, Columbia University, it was found that the proportion of the Children's Interest List to be found in these present-day texts ranged from 21 per cent to 64 per cent."

Recommendations.—(1) The teacher should tie himself to no particular text-book in mapping out a course in general science. "Let the Children's Interest List direct the way. Have the text which contributes most to the interests of the pupils in the foreground and use for references the others which have stressed and developed the special environment. Supplement these with carefully selected readings and references."

TABLE XIII

RANK AND FREQUENCY OF THE 42 MOST IMPORTANT SCIENTIFIC INTERESTS OF CHILDREN, AS INDICATED BY FREQUENCY OF APPEARANCE (POLLOCK STUDY)

Rank	Frequency	Interest	Rank	Frequency	Interest
1	349	Electricity	21.5	38	Volcanoes
2	253	Stars	23.5	37	Animals
3	243	Radio	23.5	37	Trees
4	181	Heat	25.5	36	Machinery
5	157	Lightning	25.5	36	Water-supply
6	146	Planets	27	31	Sea
7	120	Moon	28.5	30	Earthquake
8	98	Sun	28.5	30	Snow
9.5	97	Mars	31	27	Anatomy
9.5	97	Plants	31	27	Nature
11	86	Wind	31	27	Radium
12	83	Gravity	34	25	Food
13	82	Air	34	25	Stones
14	81	Aeroplane	34	25	Telephone
15	72	Earth	36.5	24	Engine
16	57	Light	36.5	24	Rain
17	51	Sound	38	23	Fishing
18	50	Gas	39	22	Flowers
19	46	Rotation	40.5	21	Photograph
20	40	Clouds	40.5	21	Seasons
21.5	38	Bacteria	42	20	Coal

STUDY NO. 33C

A Quantitative Analysis of Aims in Teaching High School Chemistry

By Jacob Cornog, and J. C. Colbert*

Problem.—To determine the relative stresses placed upon descriptive matter, useful applications, equations and problems, and theory by representative text-books, teachers' stress, and examination questions.

Method.—The investigators sent a questionary to 550 high schools in all the states of the Union. Data bearing upon this problem were taken from the 187 replies from 37 states, representing high schools having a total enrollment of 204,725 pupils of whom 18,905 (9.2 per cent) were studying chemistry. These data included (1) a page by page analysis of the five most widely used text-books: *Brownlee, McPherson and Henderson, Black and Conant, A. Smith,* and *Newell;* (2) a determination of *teachers' stress* as indicated by a compilation of 172 teachers' opinions of the relative importance of things stressed; (3) an analysis of 3609 final examination questions contributed by 83 high schools in 37 states, including a number of New York State Regents questions; and 41 final examination questions of the College Entrance Board of the New England and Middle Atlantic States.

Under each of these three investigations were considered: (1) Descriptive matter—phenomenology and properties of matter; (2) useful applications, including industrial applications and daily life; (3) equations and problems; (4)

* *School Science and Mathematics*, February, 1924. Vol. XXIV, pp. 168–173. Only the curricular phases of this investigation are here presented.

theory. "As a basis for numerical comparison [in the *teachers' stress*] each time one of these items received a first stress it was arbitrarily given a weighted value of four; a second stress, three; a third stress, two; and a fourth stress, one."

Findings.—(1) "The most widely used text-books are about ½ descriptive matter, ¼ useful applications and ⅕ theory, problems, and equation writing; also the portion given to theory becomes slightly greater the more recent the text."

2. The order of importance according to *teachers' stress* is (1) descriptive matter (approximately ⅓); (2) useful applications (approximately ¼); (3) equations and problems (approximately ⅕); (4) theory (approximately ⅕).

3. The investigators think the examination questions reveal more certainly than any other sources, the actual "existing basic aims of each teacher's effort." In these examination questions, from all three sources, there was fair agreement in giving many descriptive and few theory questions, and a poor agreement in other items. In descriptive matter, useful applications, and equations and problems the range of content of questions is undesirably wide, "nor should the 14.3 per cent of all schools which give not a single question to theory be overlooked."

4. Very little attention is given pure theory; this fact along with the preponderant attention in *teachers' stress* given to descriptive matter and useful applications in a proportion strikingly like that in text-books, would indicate that "the backbone of much high school chemistry is a parrot-like repetition of text-book matter."

5. That about ¼ of the examination questions are on equations and problems indicates an effort at thoroughness. (The investigators think this effort mostly ineffective and

think that as a corrective measure more attention should be given to insuring that the pupils "have some clear ideas of the kinetic theory, mass action, and the like, before any amount of equation writing will amount to much.")

6. "The deviations in the content of high school final examination questions . . . indicate a wide divergence in the aims in teaching chemistry in high schools."

7. No significant differences in general aims was found between small and large high schools, and between high schools in the industrial region of the country north of the Ohio and east of the Mississippi rivers.

8. The investigators believe that "high school chemistry is not primarily a memory subject and cannot successfully be taught as such."

TABLE XIV

RELATIVE IMPORTANCE OF DESCRIPTIVE AND THEORETICAL MATTER (CORNOG AND COLBERT STUDY)[1]

	Per cent descriptive matter			Per cent theoretical matter		
	Descriptive	Useful applications	Total	Theory	Equations, problems	Total
Average content, high school textbooks	55.8	25.2	81.0	13.1	5.9	19.0
High school teachers' stress	32.3	25.5	57.8	20.7	21.8	42.5
New York State Regents' questions	32.3	37.0	69.3	6.7	23.0	29.7
Average content, high school questions	42.4	24.4	66.8	8.5	24.7	33.2
Content, Entrance Board questions	34.1	24.4	58.5	12.3	29.2	41.5

[1] The data for this table are taken from the investigators' circle graphs.

STUDY NO. 34C

Report of the Committee on Reorganization of the Biological Sciences, Appointed by the Cleveland Biology Teachers Club

By Ellis C. Persing* (Chairman)

Problem.—To prepare an outline for a course in biology for the tenth grade and another for a half-year course in botany for the twelfth grade.

Method.—The Committee and the Biology Club devoted more than two years to the work of preparing these outlines which were then tried out in one or more schools before their adoption by the Club.

Findings.

TENTATIVE OUTLINE OF A COURSE IN HIGH SCHOOL BIOLOGY (CLEVELAND REPORT)

I. There is a fundamental resemblance between plants and animals

1. Protoplasm, the material out of which living things are made
   - (*a*) Microscopic examination and study of animal cells
     - (1) Single cell: Amoeba, paramoecium, vorticella
     - (2) Group of cells: Any animal tissue
   - (*b*) Microscopic examination and study of plant cells
     - (1) Single cell: Pleurococcus
     - (2) Group of cells: Leaf epidermis, mesophyll
     - (3) Cell structure: Cell wall, cytoplasm, nucleus, chloroplast (in plant cell)
     - (4) Cell activities: Food getting or food making, growth, reproduction
     - (5) Cell organization: Division of labor, tissue, organ, system

* *School Science and Mathematics*, March, 1924. Vol. XXIV, pp. 241–246.

II. There is an inter-relationship of plants and animals

1. The web of life, as shown by animal and plant communities of any vacant lot, woodland, or garden
2. The general problems of living
   (*a*) Adaptations to environment
   (*b*) Adaptations for food-getting
   (*c*) Adaptations for self-preservation and preservation of the species
3. The inter-relations of plants and animals
   (*a*) Insects and pollination
   (*b*) Study of a particular insect
      (1) Body plan
      (2) Body adaptations
      (3) Life cycle
   (*c*) Study of a particular flower
      (1) Parts: Function of floral envelope; function of essential organs
      (2) Pollination
      (3) Fertilization
      (4) Development of embryo, seed, and fruit
      (5) Problem of seed and fruit dispersal

III. The work of higher green plants has led to a differentiation of parts, a division of labor among cells

1. Differentiation of parts in embryo of seed
2. Seed germination and the establishing of embryo parts
   (*a*) Root system: Types, work, structure
   (*b*) Stem: Habits, work, structure
   (*c*) Leaf: Work, structure
   (*d*) Flower: Work
   (*e*) Seed: Purpose
   (*f*) Fruit: Classification, structure
3. Special adaptations for specific environments
   (*a*) Xerophytic habit
   (*b*) Mesophytic habit
   (*c*) Hydrophytic habit

IV. The green plants are the foundation of the world's food supply

1. The manufacture of carbohydrates
   (*a*) The leaf, the chief organ of photosynthesis
   (*b*) The raw materials: Source, route to working cell

(*c*) The machinery of the cell: Chloroplast
(*d*) The power: Red and blue rays of light
(*e*) The process
(*f*) The finished product
(*g*) The waste product

2. The manufacture of protein
3. The manufacture of fat
4. The use to which food is put: Assimilation, respiration, growth

V. The oxygen cycle, carbon cycle, and nitrogen cycle in connection with plant and animal welfare

VI. The problem of food-getting has led to special adaptations among plants and animals

1. Dependent organisms
   (*a*) Parasitic habits among plants: Bacteria, mold, dodder, mistletoe
   (*b*) Saprophytic habit among plants: Bacteria, yeast, mold
   (*c*) Parasitic habit among animals: Hookworm, tapeworm, loss of parts, degeneration
2. Independent organisms
   (*a*) Animals: Protective coloration, mimicry, carnivores, herbivores, insectivores, omnivores

VII. The food questions among plants and animals relates them closely to man

1. Insects are closely related to human welfare because of their destruction of crops, stored food, trees, clothing, etc.
   (*a*) Crops: Chinch bug, Colorado potato bettle
   (*b*) Stored food: Weevil, cockroach, ant
   (*c*) Trees: Tussock moth, gypsy moth
   (*d*) Clothing: Clothes moth
2. Fungi are closely related to human welfare because of their destruction of food and food-producing plants
   (*a*) Wheat rust, corn smut, molds, mildew
3. Insects are closely associated with disease organisms which they carry to man and beast
   (*a*) Fly and typhoid
   (*b*) Mosquito and malaria
   (*c*) Fleas and plague

4. Micro-organisms finding food and favorable conditions in the human body are the cause of infectious disease
   (*a*) Infectious disease; non-infectious
   (*b*) Contagious disease; non-contagious
   (*c*) Sources of infection
   (*d*) Incubation period
   (*e*) Immunity
      (1) Artificial or acquired: Vaccination; antitoxin
      (2) Natural

VIII. The assimilation of food has led to a differentiation of plants or a division of labor among animal cells

1. Problems of digestion
   (*a*) Foods: Food values, vitamines
   (*b*) Organs of digestion: Digestive glands, enzymes, enzyme action
   (*c*) Absorption
2. Circulation: Purpose, organs
3. Respiration: Purpose, organs
4. Excretion: Purpose, organs
5. Nervous system: Control of body action

IX. There is a continuity of life, whether plant or animal

1. Survey of reproduction
   (*a*) Asexual
      (1) Cell division: In one-celled organisms; its modification in cuttings, layering, and grafting
      (2) Spores: In Algae, Fungi, ferns
   (*b*) Sexual reproduction: In Algae for simplest form; in ferns for alternation of generations; in flowering plants; in fish; in birds; in mammals

X. Life shows progress—the present may be interpreted in terms of the past

1. Evolution
   (*a*) Explanations
      (1) Lamarck—"Acquired Characters"
      (2) Darwin—"Natural Selection"
      (3) Weissmann—"Germinal Selection"
      (4) De Vries—"Mutations"

(*b*) Evidences
(1) Paleontology
(2) Embryology
(3) Geographical distribution
(4) Classification
(5) Experiment

XI. Man may control the production of forms and has within his power, race improvement of both plants and animals

1. Laws of inheritance and their application to plant improvement; human improvement

OUTLINE OF A COURSE IN HIGH SCHOOL BOTANY (SUGGESTED) TWELFTH YEAR (CLEVELAND REPORT)

I. The fundamental difference between plants and animals

1. The uses of plants to man, both direct and indirect[1]

II. The structure of the plant

1. The cell
2. The four parts of the seed plant and the uses of each part to plant itself
3. The study of the roots
   (*a*) The fibrovascular system
4. The stem
   (*a*) The fibrovascular system in the monocots and dicots
5. The leaves
   (*a*) Epidermis, mesophyll, chloroplasts, etc.
6. The study of the flower
   (*a*) Use of the flower to the plant
   (*b*) Parts of the flower
   (*c*) Development of the flower into the fruit and seeds
7. Experiments
   (*a*) Cell of the elodea under the microscope: Show cell-wall, cytoplasm (protoplasm outside the nucleus), chloroplasts
   (*b*) Cross section of the leaves showing epidermis and mesophyll

[1] Have the pupils bring in a list of things with which they have come in contact from the time of getting up until they arrive at school. Trace directly or indirectly to plants such articles as furniture, house, clothing, food, fuel, heat, light, oxygen.

(*c*) Cross section of the monocot stem and the dicot stem
(*d*) To show the path water takes in plant: Take seedling of bean in eosin to show the fibrovascular system

III. Nutrition and processes connected with this activity

1. Photosynthesis
2. Respiration
3. Transpiration
4. Method of obtaining raw materials
5. Digestion, enzymes, assimilation
6. Experiments
   (*a*) Tests for starch, sugar, fats, protein
   (*b*) Transpiration
   (*c*) Tropisms
      (1) Geotropisms—negative and positive
      (2) Heliotropism

IV. Reproduction

1. Vegetative
2. By means of stems, roots, leaves; budding and grafting
3. Sexual
   (*a*) The purpose of the flower to the plant
   (*b*) The two essential parts of the flower
   (*c*) Pollination and the agencies which accomplish this process
   (*d*) Process of fertilization
   (*e*) Development of the embryo
   (*f*) Study of the parts of the seeds, seed dispersal, and germination of the seed
4. Experiments
   (*a*) The growth of the pollen tubes
   (*b*) Escape of the plant from seed coat
   (*c*) Stages in the development of the embryo
   (*d*) Stem grafting or budding by pupils (if time permits)
   (*e*) Reproduction of geraniums from slips

V. Evolution of plants

1. The four groups into which plants are divided
   (*a*) Thallophytes—Bacteria, Fungi, Algae
   (*b*) Bryophytes—mosses especially
   (*c*) Pteridophytes—ferns and their relation to the formation of coal

(*d*) Spermatophytes—gymnosperms and angiosperms

2. Especial emphasis on the structure, nutrition, and reproduction
3. Uses of each group to man, either uses to the present or the past
4. Uses of plants in the industries
   (*a*) Bacteria with relation to milk, cheese, refrigeration, cold storage, etc.
   (*b*) Fungi, as food (*National Geographic Magazine*, May, 1920)
      (1) Tree fungus, molds, etc.

VI. Identification

1. Description of trees and shrubs
2. Characteristics of growth
3. Habitat
4. Description of leaves, flowers, fruit
5. Collection of leaves in the form of an herbarium
6. Suggested list of trees
   (*a*) Ornamental and shade trees—ash, beech, birch, chestnut, cedar, linden, maple (sugar and Norway), oak (black, pin, red, white), pine, spruce, sycamore, tree of heaven
   (*b*) Fruit trees—apple, pear, cherry, peach, plum, quince

VII. Plant breeding

1. Origin of new species
2. Mutation
3. Selection
4. Hybridization

VIII. Forests

1. Definition
2. Kinds—pure, mixed, deciduous, evergreen
3. Uses—for timber, to prevent erosion, for influence on climate and water-supply
4. Forest fires
5. Needs of conservation

IX. How to beautify the home surroundings

1. Simple plan for beautifying the home
   (*a*) A small vegetable garden—include four or five kinds of vegetables

(*b*) Flower beds along the fence, house, garage
(*c*) Vines, early spring bulbs, annuals, perennials
(*d*) Shrubs—for a hedge and group planting on lawn, between lots
(*e*) Ornamental trees
(1) One fruit tree of standard size with grafts of several varieties
(2) Trees between the sidewalk and the curb

X. The main points in the lives of great scientists and their contributions to science
1. Louis Pasteur (his life by Vallery Radot)
2. Charles Darwin
3. Luther Burbank (*New Creations in Plant Life*)

XI. Suggested trips
1. To a sugar camp
2. To parks
3. Visit to some well laid out garden
4. Visit to the filtration plant

STUDY NO. 35C

A Study of the Illustrative Material Found in Ten Biology Texts

By Glenn Stiles*

Problem.—To determine the quality and quantity of illustrative material in the text-books of biology, as an aid to selecting a text-book.

Method.—The text-books of biology given in Table XV were examined to find the number of illustrations, the number of the various sizes of illustrations (from $\frac{1}{9}$ of a page to a whole page) appearing, and the percentage of illustration (found by dividing the space given to illustrations by the total page space). The pictures were then

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analyzed for quality as a basis for determining the percentage of good illustrations. The criteria for judging the illustrations follow:

Good illustrations

1. Well contrasted in blacks and whites or colors;

2. Clear, that is, focusing attention sharply upon the parts which the author wished to stress;

3. Apt.

Medium and poor illustrations

1. Poor in contrast;

2. Too small for the object portrayed;

3. Too detailed.

Findings.—(1) The order of frequency of the various sizes of illustrations found in the text-books examined was $\frac{1}{6}$ page, $\frac{1}{9}$ page, and $\frac{1}{3}$ page. There were found to be about four times as many $\frac{1}{6}$ page as full page illustrations and about eight times as many $\frac{1}{6}$ page as $\frac{2}{3}$ page illustrations, the least frequently appearing size.

2. "The text-books using the greatest number of pictures or the greatest number of large pictures are not necessarily the best illustrated."

3. The age and the kind of text-book can be closely approximated by the type of figure used. The older text-books are anatomical; the next type are evolutionary; the latest have been civic, that is, economic and social.

4. "The civic biologies have in general more illustrations than the older general biologies."

5. "Graphs, tables, and maps appear only in the later texts."

6. The grade placement for which a text-book was intended was found to have no effect upon the amount of illustrative material used.

7. "The more attractive text-books have fewer small pictures."

TABLE XV

DATA RELATIVE TO THE ILLUSTRATIONS IN VARIOUS TEXT-BOOKS OF BIOLOGY (STILES STUDY)

Text-book	Published	Pages	Illustrations	Per cent of illustrations	Per cent of good illustrations
First course in biology, Bailey and Coleman	1908	607	757	24.7	79.5
General biology, Needham	1910	511	290	17.7	60.9
Elementary biology, Peabody and Hunt	1913	170	252	50.3	69.0
Introduction to biology, Bigelow	1914	414	108	7.1	78.9
A civic biology, Hunter	1914	406	331	20.7	47.1
Elementary biology, Gruenberg	1919	514	225	18.8	95.9
Biology for high schools, Smallwood, Revelly, Bailey	1920	550	424	21.4	60.0
Biology for beginners, Moon	1921	548	152	14.1	59.0
Civic and economic biology, Atwood	1922	455	339	41.6	95.6
Biology of home and community, Trafton	1923	605	208	9.6	56.0
Average			308.6	22.5	70.2

STUDY NO. 36C

REPORT OF THE COMMITTEE OF CHEMICAL EDUCATION OF THE AMERICAN CHEMICAL SOCIETY

BY NEIL E. GORDON* (Chairman)

Problem.—To construct a standard minimum high school course in chemistry.

Method.—The Committee of Chemical Education of the American Chemical Society, at its April meeting, 1923, formulated 4 objectives to govern its work in constructing the outline, and 11 objectives to guide the high school

* *Journal of Chemical Education*, May, 1924. Vol. I, pp. 87–93.

teacher in developing the work from the outline. During November, 1923, the tentative outline was published,[1,2] and along with it, an invitation to teachers of high school chemistry and others interested to submit criticisms. In February, 1924,[3] regional representatives were announced, each to organize his own locality and arrange for receiving and tabulating these criticisms. At the April meeting, 1924, the Committee "revised the 'Standard Minimum High School Course in Chemistry' so that it was as near as possible in accordance with the 30,000 criticisms which had been made available . . . during the past six months."

Findings.

REVISED REPORT OF "A STANDARD MINIMUM HIGH SCHOOL COURSE IN CHEMISTRY"

The following objectives have governed the committee in its work:

A. To prepare an outline for high school chemistry which is satisfactory for students who wish to get a general knowledge of chemistry as well as for those who are going to college.

B. To list only the minimum essential topics which are common to all localities, so that the high school teacher will have time in developing the course to supplement these minimum topics with material which he considers especially suitable for his locality or for the future work of his students. See list of topics for supplementary work at end of this report.

C. To prepare an outline which would cover the essentials of any State requirements.

D. To prepare an outline which would be in tune with the syllabus of the College Entrance Examinations Board.

[1] *Journal of Industrial and Engineering Chemistry*, XV, 1189 (1923).
[2] *School Science and Mathematics*, XXIII, 777.
[3] *Journal of Chemical Education*, I, 33.

It is the anticipation of the committee that the following objectives will govern the high school teacher in developing the outline:

A. To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry, etc.—in a word, to show the service of chemistry to the country.

B. To develop this service in chemistry around these minimum standard topics, and, in doing so, to see that these minimum requirements are so well taught that they may be built upon as a foundation in college.

C. To use his own order of developing the listed topics.

D. To train the student in keen observation and exact reasoning.

E. To develop a careful correlation between recitation and experiment.

F. To encourage students to keep notebooks which shall be an accurate record of laboratory experiences expressed in concise, clear English.

G. To encourage chemistry being placed in fourth year of high school after the students have had a year of general science, and a year of biological science or physics, or preferably both.

H. To build upon the earlier science courses and knit them together in the best possible manner.

I. To encourage students to use reference books in addition to their text-book.

J. To help pupils to find themselves—*i.e.*, to discover whether they have an aptitude for further study in chemistry or applied science, and, if so, to encourage such students to continue their study of science in university or technical school.

K. The teacher is urged throughout the course to stress the general principles involved in the specific cases studied.

A. Topics for a Standard Minimum High School Course in Chemistry

I. Water

1. General distribution
2. Physical properties: Color; odor; taste; density; boiling point; freezing point
3. Solution: Solvent; solute; saturated solution; process of solution; degrees of solubility; factors affecting the solubility of a substance; suspensions

4. Impurities in water: What constitutes impurities; purification by boiling, distillation, or filtration
5. Crystallization: Water vapor; water of hydration; deliquescence and efflorescence
6. Chemical properties: Quantitative composition of water by electrolysis and qualitatively by synthesis from copper oxide; contrasts of physical and chemical change; contrast of elements and compounds; stability of water; interaction of water with active metals; order of activity; interaction with oxides

II. Oxygen

1. Preparation
   (*a*) Electrolysis of water
   (*b*) Industrial
   (*c*) Potassium chlorate (use of catalytic agent)
2. Properties
   (*a*) Physical: Color; odor; solubility in water; weight relative to air; weight of 22.4 liters
   (*b*) Chemical: Tendency to form oxides in air and in oxygen; explanation of oxidation and combustion; kindling temperature
3. Uses: Necessary to life

III. Hydrogen

1. Preparation
   (*a*) Electrolysis of water
   (*b*) Industrial
   (*c*) Action of certain metals—*i.e.*, sodium on water
   (*d*) Replacement in acids by metals
2. Properties
   (*a*) Physical: As with oxygen
   (*b*) Chemical: Burns in air; reduction by hydrogen
3. Uses (practical): Oxyhydrogen flame; balloons; hydrogenation of oils
4. Hydrogen peroxide: Properties; uses

IV. Laws, hypotheses, and theories

1. Law of conservation of mass
2. Law of definite composition (proportion)
3. Atomic theory including electron (simple treatment)

4. Law of Boyle and law of Charles, treated briefly with special reference to gases, not experimentally, but rather their application to the interpretation of change of volume
5. Law of Gay-Lussac and Avogadro's hypothesis

V. Symbols, weight, volume relations, and chemical changes

1. Atomic weights (not their derivation), use in performing simple chemical calculations
2. Molecular weights as explained by law of Gay-Lussac and Avogadro's hypothesis
3. Symbols and formulas: Their meaning and use in writing equations
4. Valence, with special reference to writing formulas
5. Equations and their use in expressing chemical changes, including gravimetric and volumetric equations
6. Problems involving (1) percentage composition; (2) weights of substances and volume of gases concerned in chemical relations; and (3) the laws of gases
7. Kinds of chemical changes: (1) Oxidation and reduction as illustrated by direct combination, decomposition, simple replacement (substitution); (2) double replacement (metathesis)
8. Energy change treated qualitatively: Heat; light; electrical energy
9. Formulas and writing of equations for reactions already studied

VI. Air

1. Percentage of oxygen and nitrogen by volume
2. Tests for water vapor and for carbon dioxide
3. Liquid air: Principle of preparation and source of oxygen and nitrogen
4. Two proofs that air is a mixture and not a compound

VII. Nitrogen

1. Occurrence
2. Properties
   (*a*) Physical
   (*b*) Chemical: Nonsupporter of combustion; general inactivity; negative tests
3. Nitrogen fixation, as illustrated by plants, synthesis of ammonia, and oxides of nitrogen
4. Uses (practical)

VIII. Oxides of nitrogen

1. Nitric oxide: Preparation; properties; tests; uses
2. Nitrogen dioxide: Preparation; properties; tests; uses

IX. Nitric acid

1. Preparation
   (*a*) Industrial (from the air)
   (*b*) Sodium nitrate with sulfuric acid
2. Properties
   (*a*) Chemical: Action of dilute and concentrated nitric acid on copper and silver; test for nitric acid or a nitrate; decomposition products of different nitrates
3. Uses: Oxidizing agent; nitrocellulose industries; high explosives (briefly)

X. Ammonia

1. Preparation
   (*a*) Decay of nitrogenous matter
   (*b*) Industrial (Haber process)
   (*c*) Destructive distillation of soft coal
   (*d*) Action of ammonium salt with nonvolatile base
2. Properties
   (*a*) Physical
   (*b*) Chemical: Basic character of water solution; ammonium radical; formation of ammonium salts; test
3. Uses: Refrigerating agent; preparation of ammonia water

XI. Acids, bases, and salts

1. General properties: Taste; action on litmus; etc.
2. Solutions: Conductors of electric current
3. Activity of acids and bases

XII. Theory of ionization (briefly)

1. How theory explains electrolysis
2. How theory explains neutralization
3. Acid and base defined in terms of ions; test for hydrogen ions and hydroxyl ions
4. Atom and ion distinguished

XIII. Sulfur

1. Occurrence
2. Extraction: American method (Frasch method)
3. Allotropic forms: Crystalline and amorphous
4. Properties

(*a*) Chemical: Direct combination with metals, for instance iron and copper

5. Comparison with oxygen
6. Uses: Vulcanizing rubber; making matches; making sulfur dioxide

XIV. Oxides of sulfur

1. Sulfur dioxide
   (*a*) Preparation: Burning sulfur; roasting of sulfide ores; action of an acid upon a sulfite
   (*b*) Properties
      (1) Physical
      (2) Chemical: Action with water (sulfur dioxide test)
   (*c*) Uses: Bleaching; reducing agent; as a refrigerant

XV. Sulfuric acid

1. Preparation
   (*a*) Contact process
2. Properties
   (*a*) Physical: Specific gravity and boiling point
   (*b*) Chemical: Affinity for water; dilute acid on metal and concentrated acid on copper; test for sulfate ion
3. Uses: Preparation of other acids, with reason for the same; manufacture of fertilizers; refining of petroleum; pickling of metals

XVI. Hydrogen sulfide

1. Preparation: Ferrous sulfide and dilute hydrochloric or sulfuric acid
2. Properties
   (*a*) Physical
   (*b*) Chemical: Combustion; action on metals; action on solutions of metallic salts

XVII. Halogens

1. Chlorine
   (*a*) Preparation: One industrial method (electrolysis of water solution of sodium chloride); one laboratory method (oxidation of hydrochloric acid using manganese dioxide)
   (*b*) Properties
      (1) Physical
      (2) Chemical: Direct combination with other elements to form chlorides; tests; comparison with oxygen

(*c*) Uses: Bleaching and disinfecting action
(*d*) Compound: Hydrogen chloride (the gas) and hydrochloric acid (the solution)
(1) Preparation: From a chloride and sulfuric acid
(2) Properties
(3) Physical
(4) Chemical: A typical acid shown by taste, action on litmus, and reaction with metals and bases; test for chloride ion
(*e*) Use as a laboratory reagent

XVIII. Carbon

1. Occurrence
(*a*) General distribution
(*b*) Allotropic forms: Diamond; graphite; amorphous forms
2. Commercial preparation of useful forms: Graphite; charcoal; lamp-black; coke; bone-black
3. Properties
(*a*) Physical
(*b*) Chemical: Affinity for oxygen; action with calcium and silicon (electric furnace)
4. Uses: Common fuels containing carbon or carbon compounds; operation of household stoves and furnaces; reduction by carbon; decolorizer; absorbent

XIX. Carbon dioxide

1. Occurrence: Relation to plant and animal life
2. Preparation: Burning carbon or a carbon compound; action of acid on a carbonate
3. Properties
(*a*) Physical
(*b*) Chemical: Nonsupporter of combustion; action with soluble hydroxide; brief treatment of its solubility in water; temporarily hard water; its role in nature; plant growth; and test for carbonate ion
4. Uses: Refrigerating; beverages; fire extinguishers; leavening agent in bread-making

XX. Carbon monoxide (teacher's demonstration)

1. Preparation: From oxalic acid; reduction of carbon dioxide by carbon
2. Properties

(*a*) Physical
(*b*) Chemical: Combustibility; reducing power
3. Uses: Reducing agent industrially; constituent of water gas, coal gas, and producer gas
4. Illuminating and fuel gases: Manufacture and uses

XXI. Metals in general

1. Definition of metal, non-metal, mineral, ore
2. Occurrence: Free; combined
3. General methods of extraction: Roasting of non-oxide ores; reduction of oxide by carbon; electrolysis of chloride, hydroxide, or oxide
4. Action of air, water (including steam) and dilute acids on the common metals
5. General methods of preparing metallic salts: Neutralization; acid plus metal; acid plus salt of a more volatile acid; acid plus metal oxide; or acid plus carbonate

XXII. Sodium

1. Preparation
   (*a*) Industrial: Electrolysis of sodium hydroxide
2. Properties
   (*a*) Physical: Metallic luster, hardness, color, power to conduct heat and electricity
   (*b*) Chemical: Flame test; action with water, with chlorine
3. Compounds of sodium
   (*a*) Hydroxide: Commercial preparation (electrolytic process); properties as typical base; use (cleaning agent, soap-making)
   (*b*) Chloride: Occurrence in sea water and earth's crust; purification; use
   (*c*) Carbonate: Preparation by Solvay process; properties; use (particularly industrial)
   (*d*) Acid carbonate: Preparation; properties; uses; active principles of baking powders
   (*e*) Nitrate: Occurrence; properties; uses
   (*f*) Flame test

XXIII. Calcium compounds

1. Carbonate:
   (*a*) Occurrence: Marble, limestone, shells

(*b*) Properties: Solubility in water containing carbonic acid (temporarily hard water), decomposition by heat, action with acids

(*c*) Industrial uses: Building material, making of quicklime, flux in iron furnaces, glass

2. Oxide: Preparation (industrial); properties; industrial uses
3. Hydroxide: Preparation; properties; uses (mortar, its hardening)
4. Sulfate: Occurrence; properties; test; uses; permanently hard water and contrast with temporarily hard water
5. Bleaching powder: Commercial preparation; uses (bleaching, disinfecting)
6. Calcium phosphate: Occurrence; preparation of fertilizer
7. Fertilizers: Presence of potassium, nitrogen, and phosphorus as ingredients

XXIV. Iron

1. Metallurgy (extraction from oxide ores—pig iron—blast furnace)
2. Cast iron: Physical properties
3. Uses of cast iron: Castings, etc.
4. Steel: Manufacture (Bessemer, open hearth, and electrical processes); carbon and manganese steels with reference to their industrial uses
5. Protective coatings to prevent corrosion of iron and steel: Tin (tinware); zinc (galvanized iron); nickel plate; enameled ware; paint
6. Compounds of iron
   (*a*) Sulfate: Preparation; properties; uses
   (*b*) Chlorides (ferrous and ferric): Preparation (laboratory); properties; uses; ferrous and ferric compounds; oxidation and reduction of iron compounds; change of valence

XXV. Aluminium

1. Metallurgy (electrolytic process)
2. Properties
   (*a*) Physical
   (*b*) Chemical: Action with hydrochloric acid and sodium hydroxide; amphoteric
3. Uses: Utensils; alloys; electrical conductor
4. Compounds

(*a*) Hydroxide: Preparation (laboratory); properties; uses, purification of water
(*b*) Sulfate (alum): Preparation (laboratory); properties; uses

XXVI. Copper

1. Purification by electrolysis
2. Electroplating
3. Properties
   (*a*) Physical
   (*b*) Chemical: Action with air and acids
4. Uses: Electrical purposes; alloys
5. Compounds of copper
   (*a*) Sulfate: Properties; uses (water purification, fungicide)

XXVII. Sources of organic compounds

1. Destructive distillation of wood: Methanol; acetic acid; charcoal
2. Destructive distillation of coal: Gas; ammonia; benzene; tar; coke
3. Distillation and cracking of petroleum: Gasoline; kerosene; vaseline; paraffin

XXVIII. Organic compounds (briefly)

1. Sugar
2. Starch
3. Acetic acid
4. Ethanol (ethyl alcohol)

B. List of Topics for Supplementary Work

Not to be required for college entrance but to be introduced to add interest to the topics in the required minimum outline and to be selected according to local importance and at the discretion of the teacher. Only suggestions for the teacher.

Adhesives. Gums, paste, dextrin, glue, casein, water glass (sodium silicate)

Artificial stone. Lime, plaster, mortar, hydraulic cement, concrete, stucco, plaster of Paris

Beverages. Charged water, soda, mineral, infusions, tea, coffee, fruit juices (artificial flavors), fermentation

Clay products. Brick, pottery, stoneware, chinaware, porcelain

Cleaning agents. Acid: Oxalic, hydrochloric; alkalies: Sodium hydroxide, soap (emulsification); special solvents: Carbon tetrachloride, benzene; composition of trade-marked cleaning agents

Coal. Composition and fuel values of different varieties; distillation of coal tar, light oil, middle oil, heavy oil, tar, pitch; relation to dyes and explosives

Dyeing. Direct and mordant dyes

Explosives. Black powder, nitroglycerol, dynamite, guncotton, trinitrotoluene

Fertilizers. Soil fertility, elements needed by growing plant and function of each; photosynthesis and carbon dioxide cycle; nitrogen cycle and function of nitrogen fertilizers; use of limestone and phosphate rock

Foods. Classification: Carbohydrates, fats, proteins, mineral matter; starch preparation from corn; cooking to dextrin and to paste; hydrolysis to glucose; sugars: Preparation and refining of beet and cane varieties; conversion to caramel; inversion; fats: Olive oil, cottonseed oil, butter, oleomargarine, hardening oils by hydrogenation; protein: Albumins, casein, gluten, peptones, gelatin, vitamins

Glass. Manufacture: Crown, flint, lead, special glasses, coloring of glass

Ink. Iron ink, organic dye ink, carbon ink

Leavening agents. Baking powders (composition and reaction), yeast, soda

Matches. Ordinary and safety types

Metals. Used for basic purposes: Iron, copper, aluminum, lead; for ornament: Gold, silver, nickel; for alloys: Bronze, brass, solder, type metal, antifriction or bearing metals, fusible metal; alloy steels; tests for metallic iron

Nitrogen fixation. Manufacture by the arc, Haber, and cyanamid processes; relation to fertilizers, explosives, and dyes

Paint, varnish, etc. Oil paints and driers, varnish, shellac, copal, linseed oil, oil cloth, linoleum; pigments: White lead, red lead, iron oxide, lead chromate, zinc white, lithopone

Paper. Manufacture treated briefly

Petroleum. Fractional distillation into burning oils, solvent oils, lubricants, paraffins; problem of gasoline supply and possible exhaustion of petroleum

Photography. Blueprints, plates, films, prints, toning, etc.
Poisons and common antidotes. Common inorganic drugs
Preserving. Sterilizing, pasteurizing, desiccating, pickling by salt and sugar; common chemical preservatives and tests for them
Refuse Disposal. Sewerage, garbage; fermentation and putrefaction; civic problems; disinfectants and deodorizing agents
Silicates. Treated briefly
Textile fibers. Natural and artificial silk; wool: scouring, bleaching, felting, etc.; cotton: Bleaching, mercerizing, etc.
Wood. Distillation of wood to produce methanol, acetone, acetic acid, charcoal

C. Additional Topics

Not to be required for college entrance but to be added if time permits.

Alloys, other than those containing copper
Arsenic insecticide
Bromine and iodine, treated similar to chloride
Catalysis
Colloids, common examples and their application
Electromotive series
Electronic structure of matter, simple interpretation
Gold
Hydrogen equivalent (reacting weights not atomic weights)
Hydrogen sulfide with special reference to treating for certain metals
Iron compounds: Oxides, hydroxides, and sulfates
Lead: Properties, uses, and compounds
Magnesium: Properties, uses, and compounds
Mercury: Properties and uses of the metal and of the chlorides
Periodic table
(*a*) Elements arranged in order of atomic weights
(*b*) Relation of valence to group numbers
(*c*) Gradual transition from metals to nonmetals in passing from Group I to Group VII
(*d*) Variation of metallic nature with variation of atomic weight within the group
(*e*) Single elements as types of groups
(*f*) Statement of Periodic law

Phosphorus: Preparation, properties, and uses
Radium and radio activities
Rare gases of the air
Silver: Properties and uses; relation to photography
Zinc: Metallurgy, properties, uses, and salts

STUDY NO. 37C

Overlapping in Chemistry

By Leonard Vincent Koos*

Problem.—To determine whether there is an overlapping of high school and college courses in chemistry.

Method.—The random sampling of standard schools in the north central states used in this investigation included the following: 26 high schools, representing cities of 10,000 population or over, distributed among 6 states, and 41 colleges scattered in 11 states; these higher institutions were all of the college type except three state and one private university.

Comparisons of the amount of supplementary materials used, of methods, of size of sections, of length and number of periods, and of opinions as to differences which do and which should exist between high school and college courses in chemistry were secured through a questionary answered by 67 instructors of chemistry in these schools. A comparison of the content of high school and college courses in chemistry was made from an analysis of text-books and

* *The Junior College.* Research Publications of the University of Minnesota, Education Series, No. 5. Minneapolis: The University of Minnesota, May, 1924. pp. 474–493. A digest under the title "Overlapping in High School and College," is found in *Journal of Educational Research*, May, 1925. Vol. XI, pp. 322–330.

laboratory manuals[1] the use of which was reported in the questionary.

The college courses considered were "general inorganic," "general," and "elementary" chemistry; where a college offered two courses in general inorganic chemistry, one for those with and the other for those without a unit of high school chemistry, the latter was the one designated for description in the questionary.

The two college text-books most commonly used by these schools were McPherson and Henderson, *Course in General Chemistry*, and Smith, *General Chemistry for Colleges;* the three high school text-books chosen were Brownlee and Others, *First Principles of Chemistry* (Revised Edition), McPherson and Henderson, *Beginning Chemistry*, and Smith, *Elementary Chemistry.* These last two text-books, which ranked respectively third and fourth in frequency of use in these schools, were substituted for Dull, *Essentials of Modern Chemistry*, which ranked second, because "the same authors' college texts were represented in this study."

[1] The investigator's statement that "this procedure has its justification in the fact that deviations from these texts are not at all common," is borne out by results of this investigation: ". . . 19 of the 26 high schools make no, or practically no, omissions from the text-book used, the remainder excluding only some or all of the inorganic chemistry"; ". . . 30 [of the colleges] report no omissions; 6, the small amount of organic work in the text used; 1, the marsh gas series; and 3, 'very little.'" ". . . 34 of the 41 colleges report no manual supplementary to the one accompanying the text. For the seven listing supplementary manuals, the additional exercises—at most a few in number—are in qualitative analysis. Twenty of the 26 high schools report no supplementary manual. Where exercises are added they are in the nature of 'everyday' problems. In almost all instances the manual intended to accompany the text-book reported is the one used."

In each of these five text-books, a determination was made of the number of lines devoted to the following subdivisions of chemistry, and of the percentages these numbers are of the total content:

Common Elements

1. Occurrence
2. Preparation
3. Physical properties
4. Chemical properties
5. History
6. Uses
7. Compounds—preparation
8. Compounds—description and properties
9. Compounds—uses

Other subdivisions

10. Rarer elements
11. Organic compounds
12. Processes
13. Principles, etc.
14. Chemical laws and their interpretations
15. Definitions and explanations
16. Questions
17. Problems
18. Summaries and restatements

A similar determination was made of the number of lines and percentages of space devoted to each experiment in the five manuals accompanying these texts. All lines reported were reduced to the same basis in order to make the data readily comparable.

Findings.—(1) The total content of these high school text-books is about ¾ that of the college texts; and "in all but 4 of the 18 subdivisions, the average college amounts exceed the high school amounts."

2. "As far as it is to be concluded from the data presented, it may be said that, although college texts are more extended than high school texts, the relative recognition of the several subdivisions does not differ widely, excepting that the former stress compounds (especially their preparation and properties), the rarer elements, and principles more than do the latter, while the latter make more of uses (both of elements and compounds), organic materials, and pedagogical features such as questions and summaries. Furthermore, the similarities far exceed the differences."

3. If processes, laws, principles, and definitions "may be assumed to comprehend the more theoretical portions of the course in chemistry, . . . the theoretical portions of the college texts can thus be said to exceed those of high school texts by 4 per cent—an appreciable but hardly extraordinary difference."

4. ". . . although there is considerable variation [in the number of illustrations] from text to text, the average number in the two groups [high school and college texts] is almost identical." ". . . the overlapping illustrations include roughly $\frac{3}{5}$ and "$\frac{2}{3}$ of all those appearing, respectively, in the college and high school texts analyzed."

5. The average college text contains "the treatment of approximately a sixth more topics than the high school texts." There is "a difference of almost 30 lines in the average extent of treatment of these topics,[1] a difference which amounts to about 50 per cent of the average treatment in high school texts."

6. ". . . the laboratory portions of college and high school courses in chemistry resemble each other vastly

[1] Topics refer to "each common element, each rarer element, each 'process,' each law, etc."

more than they differ . . ." ". . . they cannot be far from identical in major aspects."

The average precentages of common materials found in both of the college and all three of the high school manuals is "72.59 for college and 67.69 for high school experiments. When to these amounts and percentages are added those of experiments found in both groups, but not in each text of both groups, the totals amount to almost all the exercises, roughly 99 and 95 per cent for the two groups of manuals, respectively. This leaves only about 1 and 5 per cent, respectively, peculiar to college and to high school manuals."

"The essential difference seems to be not so much in numbers nor in the nature of the experiment topics found in the manuals as in the number of subexperiments introduced," suggesting a more extended detail which assures for the fields represented a somewhat more thoroughgoing extent of experimentation and exploration in college than in high school.

7. ". . . the differences [in method] are those of more lecture and quiz and less recitation in college than in high school while at the same time there is much overlapping of procedure as well as of content."

8. There is "something like the same extent of class contact between instructor and student in college as in the high school."

9. "Most of the measures of extent of materials covered favor the college course. These have a larger total amount of reading in connection with classroom work, a somewhat but not strikingly larger number of pages per clock hour of class work, a larger number of topics dealt with, and a larger number of lines per topic. The exception is in the amount of material to be read in connection with laboratory

exercises, which may be regarded as a minor factor, especially as college courses contain more subexperiments."

10. With respect to differences in content, "more material, more detail, and more theory in the college course are each believed to obtain and are regarded as desirable of achievement by large proportions of instructors." ". . . while a considerable proportion recommend that the college course be more advanced, no one [directly] volunteers a belief that it *is* so . . ." "Almost as large a proportion urge that the high school courses stress more than the college courses the more practical aspects." ". . . while almost a fourth of the group believes that there is a difference of method, no one seems to propose that it should exist. A small number believe that no difference exists or should exist."

11. "Median class sections do not differ widely, although the upper range is larger for college than for high school."

12. Chemistry is taken predominantly by students in the last year of high school and in the first year of college.

Conclusion.—(1) "Although there are some differences between high school and first college courses in chemistry, they are remarkably alike." ". . . if the materials presented in high school courses may be presumed to be secondary in character, there is relatively little in these first college courses not purely secondary. Moreover, if a student takes the course in general inorganic chemistry in college after having had the high school course, which is often done, he is repeating almost all of it. Even in that relatively small proportion of higher institutions where such a student enters upon a course in general inorganic chemistry presumed to be administered for those who offered the high school unit for admission, there must be a large amount of repetition."

STUDY NO. 38C

Life Activities and the Physics Curriculum

By M. E. Herriott*

Problem.—To determine from a study of the extent to which activities involving elements of physics are carried on by various groups in daily life whether physics should be taught in mixed or segregated classes.

Method.—The investigator divided 576 activities, involving mechanics, heat, sound, light, magnetism and electricity, and invisible radiations, into three lists: (1) "Those things which people often have others do for them," as "Test the charge of storage batteries with a hydrometer"; (2) those which, if done at all, people do for themselves, as "Buy an electric motor"; (3) "those things about which people think," as "Why we 'hear the ocean' in a sea-shell." These three lists were checked by six groups of people "to indicate the extent to which the activities listed entered into their lives"; (1) "boys of high school age"; (2) "men of laboring occupations"; (3) "men of sedentary occupations"; (4) "girls of high school age"; (5) "women not housewives"; (6) "housewives."

Findings.—The relative interest of the different groups of people in the various divisions of physics as indicated (graphically) by their reactions to the items of the questionary show:

1. "Physics as a whole enters to the greatest extent into the life of boys, second, into the life of men, third, into the life of girls, and least into the life of women."

* *School Science and Mathematics*, June, 1924. Vol. XXIV, pp. 631–634.

2. "Activities involving the principles of sound and light enter more largely into the life of girls and women than into the life of boys and men."

3. "Activities involving the principles of mechanics, heat, magnetism and electricity, and invisible radiations are preponderantly participated in by boys and men, with boys distinctly leading."

4. "Boys, laboring men, and housewives tend to do things themselves if they know how, while men of sedentary occupations, women who are not housewives, and girls tend to have others do things for them even when they know how."

5. "Although principles of physics enter quite largely into the life of girls, yet they are not doing a great deal that involves physical principles. Rather, they are having such things done for them. But they are thinking to a considerable extent about things which involve the principles of physics."

Recommendations.—In view of these findings and of the fundamental assumptions: (1) "That physics should be based upon the interests and knowledge of those taught, and (2) that it should be made to function in their lives," the investigator recommends that:

1. "Physics, as now taught in the high school, should be given primarily to boys, because physical principles and facts enter most largely into their lives."

2. "Boys and girls should be segregated in physics classes because of their different centers of interest."

3. "In boys' classes, the order of emphasis [which might also well be the order of treatment] should be magnetism and electricity, invisible radiations, mechanics, heat, sound, and light."

4. "In girls' classes, the order of emphasis [which might also well be the order of treatment] should be light, sound, invisible radiations, mechanics, heat, and magnetism and electricity."

5. "In boys' classes, the manner of treatment should be such as to involve actual operation of physical principles with apparatus handled by the boys."

6. "In girls' classes, the manner of treatment should be more that of answering intellectual curiosity and demonstration, rather than the actual physical participation on the part of the girls."

7. "Pupils should be taught in such a way as to answer, or help the pupil answer, a great many questions which involve some knowledge of physics, but which do not require a closely organized system of laws for a satisfactory understanding. This [should be given] in addition to much of the more closely organized work already taught."

STUDY NO. 39C

The Determination of the Technical Vocabulary of the School Subjects

By Luella Cole Pressey*

Problem.—To ascertain what technical words appear in text-books in general science, physics, chemistry, biology, geography, and physiology, and to obtain some estimate as to the comparative importance of each technical word thus appearing.

* *School and Society*, July 19, 1924. Vol. XX, pp. 91–96.[1]

[1] Only the parts of this very extensive study which bear upon science are here summarized.

Method.—Text-books in wide use were selected for analysis. Each text-book was read by at least two readers who read the whole book and copied down all the words which they thought a child might have difficulty in understanding. The words found by each reader were listed; all new words found on each succeeding reading were added at the end of the list; more and more readings were listed until three consecutive readings added less than one per cent of new terms. This number of readings marked the "saturation point" for each subject; the lowest was eight, for chemistry.

To determine which words on the various lists were most important, all teachers in the Ohio State University Summer Quarter Session were sent lists in the subjects they taught; they were told to mark with two checks the words which they considered absolutely essential; with one check, those they considered important but not essential; and to leave unmarked those they considered not important at all. These marked lists, when returned, were sorted according to subjects and were tabulated. Double checked words were given two marks; single checked words, one mark. The sum of the marks gave comparable combined judgment with respect to a word's importance in the opinions of the teachers marking the lists.

The words were divided into four classes: (a) those which received $\frac{1}{2}$ or more of the possible number of checks (termed the "essential vocabulary" of the subject); (b) those which received from $\frac{1}{4}$ to $\frac{1}{2}$ the total possible number of checks (termed the "accessory" vocabulary); (c) those which received less than $\frac{1}{4}$ but were found in $\frac{1}{3}$ or more of the text-books, that is, words appearing in text-books even though not used in teaching; (d) words receiving less than $\frac{1}{4}$ of the possible number of checks and not appearing in $\frac{1}{3}$

of the texts. This last class was eliminated; the other three classes were differentiated by different kinds of type. A "common science vocabulary" to express the overlapping vocabulary from one branch of science to another was constructed. Also, in addition, the overlapping of each branch of science upon each of the other branches was determined and indicated.

Findings.—(1) Since, in the opinion of several foreign language teachers, the acquisition of eight hundred to a thousand words in a new language is a very sizable vocabulary for the result of a year of study, "the pupil in any of the sciences . . . has as great, or a greater, vocabulary to master wholly aside from acquisition of considerable subject matter! The length of the general science list certainly leads one to question the advisability of the present type of text in this subject, since it contains a longer list of technical words than any other subject."

2. The list should emphasize the hard words in the subject which are apt to be stumbling blocks and which are not apt to be learned from general reading. The pupils must be taught these terms as part of the training in each subject. The teacher should be sure that the pupils know the common list and the essential vocabulary in each list plus as many of the accessory vocabulary as possible.

3. Teachers should find these lists particularly valuable in investigating the cases of pupils failing in the work, for ignorance of the meaning may indicate that the pupil has failed to grasp an entire group of ideas necessary to him in mastering the science. Lack of knowledge of the meaning of a word "usually indicates a deeper lack of meaning for a whole section of subject matter."

4. The lists should be of value in finding the vocabulary burden of a particular text by finding the proportion of

words of the list appearing in one text as compared with another.

5. The lists may be used as the basis for tests in the vocabulary of the subjects.

6. The lists might serve in making a general science text-book organized around terms found in the "Common Science Vocabulary," "thus being sure of taking up in the introductory course those scientific facts appearing most constantly and in the greatest number of conditions. Emphasis on these comparatively few basic principles might well be a more useful course than the type given at present, whose object seems to be to include the greatest possible assortment of facts."

TABLE XVI

NUMBERS OF WORDS BELONGING IN "ESSENTIAL," "ACCESSORY," AND "NOT NECESSARY" VOCABULARIES FOR VARIOUS BRANCHES OF SCIENCE (PRESSEY STUDY)

	Essential vocabulary	Accessory vocabulary	Not necessary	Totals[1]
Common science list	191	24	...	215
General science	916	648	...	1564
Biology	675	677	41	1393
Chemistry	765	488	44	1297
Physics	709	331	...	1040
Geography	313	690	129	1132
Physiology	293	493	80	866

[1] The total number of words for each subject includes the words in the "Common List."

STUDY NO. 40C

Current Practices in the Teaching of Science in the Seventh and Eighth Grades

By Lois Meier*

Problem.—To determine the concensus of opinion among teachers of the seventh and eighth grades as to "what materials should be offered" in general science, and what methods of presentation should be used.

Method.—The investigator sent a two-part questionary to 150 teachers of seventh and eighth grade science in public schools in the United States. Part I contained a list of 75 exercises chosen after a careful examination of text-books and manuals of general science. "An effort was made to include representative exercises from each unit of subject matter that commonly occurs in a thorough course in science in the ninth grade," but "it was not intended that the list should include every exercise which might be carried out under each unit of study." In this list were 37 exercises of the "pure science" type, "organized around the principles of some particular branch of science," and 38 of the practical or applied type "related to common experiences in the everyday life of the individual." The teachers were asked to check approximately the third of the exercises which they considered the most valuable, and approximately the third which they considered the least valuable.

In Part II, the teachers were asked to mark the items *D*, *I*, or *G*, to indicate respectively whether they used the demonstration, the individual, or the group method in presenting the various exercises. They were also asked to

* *General Science Quarterly*, November, 1924. Vol. IX, pp. 1–7.

indicate whether they would vary the method were all facilities for laboratory work at hand.

Sixty-six questionaries were returned from 29 different states and the District of Columbia; of these replies, 53 were used in preparing the table of exercises which follows.

Findings.—(1) Of the 25 exercises ranking as most valuable 23 are of the practical or applied-science type. Of 11 which were considered least valuable, 10 are of the pure science type. "This indicates conclusively that opinion favors the practical, more humanized type of science in the seventh and eighth grades."

2. "The concensus of opinion among teachers actually engaged in the work of the seventh and eighth grades, as shown by this investigation, indicates that the science material for these grades should be organized around problems of everyday life."

3. Of the 25 exercises ranking highest on the list, 56 per cent are of a physical nature and 44 per cent of a biological nature. This fact "indicates a tendency to disregard the ordinary boundary lines of the science subject in the seventh and eighth grades."

4. "There is great variation shown in the method used by teachers in presenting exercises. This [fact] suggests that the method depends to a large extent upon the nature of the problem."

5. "Of the 53 reports used in this study, 42 considered the problem of method. The largest number of teachers marking any one exercise was 35. Eight teachers would use the demonstration method solely; 19 would use the demonstration method in 60 per cent or more of the exercises; 8 would use the individual method for 50 per cent or more of the exercises checked; 2 would use the group method for 50 per cent or more of the exercises. These results

show a preference for the demonstration method. Comments indicate, however, that practice is governed in many cases by circumstances rather than by needs of the children."

EXERCISES[1] IN GENERAL SCIENCE (MEIER STUDY)

*1. Learn how to use a fire extinguisher.
*2. Learn what is done to keep drinking water pure.
*3. Learn how house-flies may carry disease germs.
*4. Learn how typhoid fever is transmitted.
*5. Learn how disease germs may get into milk.
*6. Learn why boilers and pipes in basements are covered with asbestos.
*7. Learn how to recognize a few constellations.
*8. Learn how a fuse may be replaced when it has burned out.
*9. Learn what kinds of food give energy to the body.
*10. Learn how to read the electric meter.
*11. Learn how to stop a leak in a water faucet.
*12. Learn how to take care of milk in the home.
*13. Find out how cotton goods may be distinguished from wool.
*14. Learn how short circuits are formed.
15. Determine the effect of evaporating liquids upon the temperature of bodies.
16. Learn how to purify water by distillation.
*17. Learn how the electric bell operates.
*18. Learn how to protect clothing from moths.
*19. Learn how insects that injure plants may be destroyed.
*20. Make a list of fires reported in the daily newspapers, and tell whether they were avoidable or unavoidable.
*21. Learn where anthracite and bituminous coal are mined, and learn why one is more expensive than the other.
*22. Learn how a fireless cooker is used.
*23. Learn what is done with garbage in your community and the expense of having it removed.
*24. Learn how coke and charcoal are made, and the use of each.

[1] The exercises are arranged in order: Those at the head of the list were considered most valuable and those at the foot least valuable by the greater number of teachers represented. Exercises of the "practical type" are starred.

*25. Learn the organization of your health department and its duties.
26. Determine whether cold air is heavier than warm air.
*27. Learn in what way use is made of the law that water seeks its level.
28. Determine the effect of heat on water.
29. Demonstrate how carbon dioxide is made.
*30. Study traffic rules.
*31. Find out how soils are formed.
32. Determine whether air occupies space.
*33. Find out what ten different kinds of birds eat.
34. Show how a lever is used in doing work.
35. Demonstrate how milk is pasteurized.
36. Determine by experiment the products formed by a flame.
37. Demonstrate that green plants give off oxygen.
*38. Learn how to get rid of roaches in the home.
39. Prove by experiment the presence of water vapor in the air.
40. Show how a lift-pump works.
41. Determine what makes some water "hard."
42. By experiment prove that water seeks its level.
*43. Learn why "quarter in the slot" gas meters may be dangerous.
*44. Make soap.
45. Prove that water and carbon dioxide are produced in the human body.
46. Determine how a magnet acts towards different substances.
*47. Make a pin-hole camera.
48. Determine whether substances take fire at the same temperature.
*49. Learn how starch is made by plants.
50. Determine the temperature of boiling water.
51. Determine the ability of soils to hold water.
*52. Learn why radiators can be made hot quicker with steam than with hot water.
53. Test for carbohydrates, fats, and proteins in food.
*54. Learn the effect of air currents on evaporation.
*55. Make a list of the different things sold in the local market for the destruction of house-flies.
56. Prove that growing yeast plants produce carbon dioxide.
57. Show how water carries heat.
58. Determine whether moisture is given off by growing plants.

59. Find out the mechanical advantage and the efficiency of a pulley system.
60. Prove that sound travels in waves.
*61. Learn how gases pass into and out of the leaves of a plant.
*62. Make a grapical comparison of the Fahrenheit and Centigrade thermometer scales.
63. Freeze some ice cream and study the principles involved.
64. Demonstrate how starch is digested.
65. Measure the amount of work done in climbing stairs.
66. Prepare hydrogen and learn its properties by experiment.
67. Determine the composition of water.
68. Determine whether light travels in a straight line.
69. Determine by experiment that the loss of weight by an object immersed in water is equal to the weight of the water displaced.
70. Determine whether liquids diffuse.
71. Show how dust explodes, using lycopodium powder.
72. Determine the relation between the amount of light and the distance from the source.
73. Determine that gases mix with one another.
*74. Calculate the possibility of overproduction of plants and animals.
75. Show by experiment how the candlepower of lamps is determined.

STUDY NO. 41C

Is There a Sequence in Secondary Science?

By George W. Hunter*

Problem.—To determine the curricular tendencies with respect to science as indicated by a study of curricular practices in representative American high schools.

Method.—In 1908 the investigator sent a questionary to 500 leading public high schools to ascertain the sequence

* *School and Society*, December 13, 1924. Vol. XX, pp. 762–766. A briefer report of this investigation is given in *General Science Quarterly*, November, 1924. Vol. IX, pp. 9–11.

of courses in science. Replies were received from 276 schools in 34 states.[1]

In 1923 the investigator sent another questionary to as many as possible of the same high schools that had answered the first, and to about 500 additional of the best public high schools in large cities, small urban communities, and to a few of the best township and district high schools. Data for comparison with the preceding investigation were secured from the 357 replies to this second questionary.

Findings.—(1) The "course in general science, biology, chemistry, and physics increased in the four-year secondary school [the junior high school figures were omitted for the sake of comparison]; while those in physiography, botany, zoology, human physiology, and scattering courses in science have decreased."

2. One reason for fewer courses in botany, zoology, and physiology is the absorption of their course materials by general science or biology.

3. "The scattering offerings, many of them 'book' courses (non-laboratory courses) have greatly decreased."

4. No very definite sequence was evident in 1908, though the biological sciences predominated in the ninth and tenth grades and physics and chemistry in the eleventh and twelfth. General science as such was practically unknown. In 1923 general science is definitely placed in the ninth grade (53.1 per cent of all ninth grade courses), biology (unified) has an established position in the tenth, and physics and chemistry in the eleventh and twelfth with improved positions. New York and a few other states were exceptions because of the Regents' Examinations but the New York teachers were dissatisfied with the sequence.

[1] Hunter, "Biologic Sciences in Secondary Schools of the United States," *School Science and Mathematics*, X (1910), 1–10; 103–111.

5. In the East and eastern Middle states, physics was found in the eleventh, and chemistry in the twelfth; in the Far West the opposite was the case. In the Middle West and South physics and chemistry were about equally represented in the eleventh and twelfth grades, with a slight tendency toward chemistry in the eleventh and physics in the twelfth. This change from conditions in 1908, the investigator thinks to be due to (1) college entrance acceptance of chemistry; (2) electron concept of matter making chemistry easier after physics.

6. Much of the increase of number of pupils taking science is due to the gain in ninth and tenth grade general science and biology.

7. Teachers think chemistry and physics gain from the earlier science courses (78.2 per cent, yes; 10 per cent, uncertain; and 11.8 per cent, no).

8. Teachers think courses in science are better related than they were 15 years earlier (71 per cent, yes).

9. Courses in science on the whole are better standardized; more hours per week, more weeks per year were devoted to science in 1923 than in 1908.

10. The great number of courses in agriculture (not included in Table XVII) is probably due to the Smith-Hughes Act.

11. Physiography is disappearing in the ninth and tending to appear as an advanced course in the twelfth.

12. Botany and zoology have almost disappeared in the ninth and are only about half as much in evidence in the tenth as 15 years earlier. Biology increased 10 to 16.09 per cent in the ninth and 7.25 per cent to 48.13 per cent of all courses in the tenth.

13. General science appeared as practically a new subject in the junior high school and in the ninth and tenth

grades. It has had a great growth in the junior high school.

14. There is a more or less definite sequence in the Far West, New Jersey, Pennsylvania, New York, Ohio, Michigan, Wisconsin, Minnesota, Iowa, and, to a lesser extent, Illinois. In New England there was more diversification and division of opinion; the sequence was lost because of more electives.

15. The 1923 results indicated a big advance in the number of hours devoted to science in the South.

16. In the great corn and wheat belts botanical courses replace to some extent the biological courses as such.

17. "The findings show that the outlook for science teaching in the secondary schools appears bright for the future."

TABLE XVII

COURSES OFFERED IN VARIOUS BRANCHES OF SCIENCE (HUNTER STUDY)

Science	Courses offered, 1908[1]	Courses offered, 1922[2]
General science	9	239
Physiography	166	135
Biology	623[3]	630[5]
Chemistry	253	398
Physics	268	400
Miscellaneous	45[4]	9

[1] Two hundred seventy-six schools reported in 1908.
[2] Three hundred fifty-seven schools reported in 1922.
[3] Including 73 in biology, and 193 in physiology.
[4] Including astronomy, geology, and sanitation.
[5] Including 299 in biology, and 158 in physiology.

STUDY NO. 42C

A Diagnostic Study of the Subject Matter of High School Chemistry

By Samuel Ralph Powers*

Problems.—(1) What are the specific tasks students are unable to do after instruction? (2) Can the difficult tasks be classified according to types? (3) Are items found difficult for students in one school also difficult for students in others? (4) What proportion of test material will be done correctly by students at different ability levels? (5) Do freshmen university students excel high school pupils in ability to do these tasks? (6) Is there a marked relation between order of difficulty of tasks for university and high school students? (7) Do university students who have studied chemistry in high school excel on these tests the students who did not study chemistry in high school? (8) Is ability to do these tasks once acquired retained or soon forgotten after students have left the chemistry class-room? (9) Does the material of the tests fairly represent the text-books which constitute the course in high school chemistry?

Method.—Tests representing the field of chemistry, made so as to be conveniently administered and objectively scored, were given just before the close of school to pupils in more than 60 cooperating schools. Various ones of these tests were given in 1920, 1921, and 1922 to pupils who were just completing a year's study of chemistry. The tests used in different years were for the most part made up of distinctly different forms except that 114 items used in 1921

* Doctor's thesis. Contributions to Education, No. 149. New York: Teachers College, Columbia University, 1924. A digest under the title, "Achievement in High School Chemistry," is found in *School Science and Mathematics*, January, 1925. Vol. XXV, pp. 53–61.

were also used in 1922. In 1920, 1921, and 1922 a grand total of 494 items was used, of which the difficulty (or extent of mastery) of 350 different test items was determined.

The tests contained items to test the following abilities: (1) To write names of given chemical formulas; (2) to write formulas of substances when the chemical name is given; (3) to construct formulas from given radicals and their valences; (4) to write chemical composition of common substances; (5) to classify elements, compounds, mixtures; (6) to classify metallic elements according to position in the activity series; (7) to complete chemical equations when the left-hand side is given; (8) to write complete equations for given chemical changes; (9) to solve numerical problems; (10) to give definitions; (11) to describe laboratory and commercial processes; and (12) to show a familiarity with the biographies of celebrated chemists.

From the results secured from this whole series, standards were secured for evaluating the subject-matter of chemistry. The smallest number of pupils counted in determining the difficulty was 418 in 12 schools; the largest, 1209 in 20 schools.

Some of the tests were also given to two University classes: The students in one had studied chemistry in high school while those in the other class had never studied chemistry in high school but were completing a year's study of University chemistry. The test results were checked against those of 20 high school chemistry classes just finishing a year of chemistry.

Findings.—(1) High school pupils acquire some serviceable knowledge of the applications of valence in building formulas and a clear-cut notion of the meaning of the terms, element, mixture, and compound. The ability to classify elements, mixtures, and compounds, would seem from the

results of this investigation to possess more functional value than any other of the abilities tested.

2. The task for accomplishment with respect to a knowledge of composition of substances "is either too large for pupils to do or the instructional material for the acquisition of this knowledge is omitted or ineffectively presented."

3. "It may be said with assurance that many students do not learn the definitions for common terminology in chemistry."

4. The exclusion of instruction in the activity of metals (the displacement series) is not warranted on the basis of difficulty.

5. It is suggested that "the inability of students to make . . . associations [between the names of famous chemists and the laws and theories bearing their names] is accompanied by failure to comprehend the meaning of the laws and theories which these men have stated."

6. Little knowledge of important industrial processes results from the instruction given in the schools which used this test.

7. There is little foundation in the results of these tests for the claim that "the student acquires a knowledge of the uses of common chemical substances." He also learns little regarding the solubilities of salts.

8. The ability to state numerical ratios between quantities of interacting substances and to make appropriate mathematical calculations is one gained by but few of the students of chemistry.

9. Few students possess the ability either to write names of chemical substances from their formulas or the formulas from their common names.

10. "Comparatively few students are able to apply even the most elementary principles of oxidation and reduction in the writing of equations."

11. It is futile to expect students to be able to write more than a few entire equations for given chemical processes or reactions.

12. ". . . those items which test ability to write complete chemical equations and those which test ability to give the composition of chemical substances are uniformly the most difficult."

13. A comparison of the tests with the material in the texts and laboratory manuals shows "that the items of the tests are not too difficult to be fairly representative of the materials contained in the commonly used text-books"; they "are probably considerably easier than would be obtained from a random sampling of the text-book material."

14. ". . . much of the work [and the text-book material in chemistry] is adapted only to the ability levels of the best 50 per cent of the pupils." The standings of some schools were so low as to suggest the entire futility of much of the high school work which is being attempted in chemistry." Much of instructional effort in high school chemistry is misspent since the tests show that those abilities, the accomplishment of which is set as the objectives of instruction, are, even to the meagre extent to which they are mastered, once acquired, rapidly forgotten.

15. "Some of the difficulties which students encounter are no doubt due to the fact that they are plunged rather suddenly into the manipulation of materials which are for them entirely new."

16. ". . . there is little or nothing in the results to indicate that pupils do certain kinds of tasks with more facility than others." "The rankings of the schools made

on the basis of these results were remarkably uniform"—schools ranking high in one division of the tests maintained their rank on the other divisions.

17. "There was a marked tendency for schools with small enrollment in chemistry to do poorly on the tests. Schools enrolling from 20 to 60 in chemistry usually did well. The very large schools did markedly better than the smallest schools but less well than the middle group."

18. No great difference was revealed between the abilities of University students who had studied chemistry in high school and students who had studied it only in University classes to do the tests, but this is a criticism of the high school curricular materials rather than of those of the University.

Recommendations.—(1) There is need for curricular studies looking to larger unit divisions than units of physics and chemistry. The organization of science should be such as to include science from many fields in an earlier fundamental course but each succeeding course should be related to and built upon the preceding courses.

2. The curriculum for science should be graded so that the elementary units provide as rich as possible an experience with scientific material and subsequent courses provide increasing opportunities for practice in attacking problems by the scientific method.

3. There is a need to determine what people need to know about science, then to organize these materials into teachable units appropriate to the ability levels of the high school pupils.

STUDY NO. 43C

An Investigation of the Scientific Knowledge Demanded for an Intelligent Reading of the Public Press

By Francis D. Curtis*

Problem.—To determine what sorts of scientific knowledge are demanded for an intelligent reading of the public press.

Method.—The materials for this investigation were 2783 newspaper articles, 2153 from the articles used by Caldwell and Finley in their study, "Biology in the Public Press,"[1] and 630 others of miscellaneous scientific content, clipped by the investigator from about two weeks' issues, consecutive, with a few exceptions, 83 complete issues in all, of 6 representative newspapers other than those sampled by Caldwell and Finley. These 630 articles included all of the scientific content of the issues selected, except the daily weather forecasts and the names of diseases and such other terms of a scientific nature as might be included in advertisements and "Death Notices."

Each article selected was considered only with respect to its scientific content which in a few cases consisted merely of a phrase, or a sentence or two, in an article of several columns' length and was of very minor importance in the article as a whole.

These 630 articles were clipped and mounted in accordance with Caldwell and Finley's technique, and along with

* Doctor's thesis. *Some Values Derived from Extensive Reading of General Science*, Contributions to Education, No. 163. New York: Teachers College, Columbia University, 1924. pp. 10–27.

[1] Study No. 31C.

the 2153 articles from the Caldwell and Finley study were then read and were given three separate analyses (*U*, *V*, and *W*); these analyses were developed from a detailed study of the material, and were built up from repeated amplifications and corrections of a tentative scheme developed from an extensive preliminary study of the articles. The 630 miscellaneous scientific articles were given three additional analyses (*X*, *Y*, and *Z*).

Analysis U.—Function (The probable effect or result accomplished by the article).

O. Those having no obvious function so far as their scientific content is concerned.

I. Those functioning merely as general interest.

II. Those functioning for the furthering or promoting of some movement, cause, etc., or for the combating of some movement or cause.

III. Those functioning as information either (1) of a useful or practical value, (2) a cultural value, or (3) a reifying value.

IV. Those functioning as advice, the criterion being, "This is or is not a prudent, desirable, or necessary thing to do."

V. Those functioning definitely as instruction, in which definite direction is furnished regarding how some prudent, desirable, or necessary thing should be done.

Analysis V.—Method of Treatment (The manner in which the material is presented).

A. The rambling discursive "space-filler" type, in which a diligent search is required to discover even the meagerest content value.

B. The incidental inclusion of a fact or facts, a term or terms in an article not primarily or predominantly scien-

tific, with no attempt at further elucidation or discussion of the science introduced.

C. The straightforward statement of a fact or group of related facts.

D. A group of facts, terms, etc.—a considerable amount of information organized into a more or less coherent whole, but with more or less additional material extraneous to the scientific exposition which nevertheless is plainly the main purpose of the article.

E. A dignified, logically organized, unified, and coherent discussion, with little or no material extraneous to the scientific interest and purpose of the article, but proceeding in a leisurely fashion contrasting sharply with the "C" type of article described above.

Analysis W.—Content (What is given or assumed as the reader's necessary equipment for a complete understanding of the article).

1. Terminology—general or specific scientific term or terms,
   (*a*) defined or explained in the article, or
   (*b*) needed or assumed as a basis for a complete understanding of the article.
2. General information of a scientific nature (such as the ordinary course in general science might reasonably be expected to furnish),
   (*a*) given by the article, or
   (*b*) required as a broad general foundation for a satisfactory understanding of the article.
3. Definite, specific information:
   (*a*) A technical process described accurately and in detail or a specific treatment outlined, neither the process nor the treatment being of a sort logically included in a general science text;

(*b*) Information or discussion of such a nature as to demand or assume on the reader's part specific technical information beyond that logically expected to be included in a text on general science, for a real understanding of the article.

4. Theory and hypothesis:

(*a*) Either a new hypothesis advanced and expounded, with arguments for it or against known competing hypotheses or theories, or

(*b*) An older theory or hypothesis mentioned or discussed in such a way as to assume a knowledge of the theory or hypothesis as a basis for understanding the article.

Mere dogmatic statements of opinion unsupported by arguments, facts, etc., sufficient to command a measure of respect for the hypothesis advanced, if not a conviction of its plausibility or even validity, were considered as insufficient to entitle the article to be listed as "4a."

Analysis X.—Classification under the Physical or Biological Sciences.

B. Those of the 630 miscellaneous articles whose scientific content falls logically under the head of biological sciences.

P. Those whose content falls logically under the head of physical sciences.

P–B. Those articles, parts of which belong under the physical, and other parts under the biological sciences.

Analysis Y.—Classification by Topics.

The 630 miscellaneous articles were analyzed to determine the number and per cent coming under the topics and divisions most frequently recurring or commonly treated in text-books of general science (sound, insect pests, light, etc.).

Analysis Z.—Scientific Terms.

A final analysis of the 630 miscellaneous articles was made to discover and list all of the scientific terms, and the number of different articles in which each term appeared one or more times. Each of these 962 scientific terms was then compared with Thorndike's "Ten Thousand Words,"[1] to ascertain in which thousand it appeared if in any. These last data were grouped to show the percentages of the total number of scientific terms found in all the 630 articles, which appear in each thousand of Thorndike's list in *The Teacher's Word Book*.

Findings.—(1) "The following facts strikingly indicate the need and importance of the broadest possible training and foundation in general science as the basis for understanding and enjoying as much as possible of the science found so abundantly in the public press:

"a. Only 13.7 per cent of these articles give scientific information and require no scientific background.

"b. A very small number of these newspaper articles (1.2 per cent) actually define scientific terms as a basis for further information contained in the articles; but more than half of those possessing scientific content contain scientific or technical terminology, an understanding of which is necessary for a full appreciation of the article.

"c. In about half the articles analyzed the scientific content consists of a term or fact incidentally included, the articles as wholes being devoted to some interest other than scientific, the full significance of the article, however, being more or less dependent upon a knowledge of the scientific content.

[1] E. L. Thorndike, *The Teacher's Word Book*. (New York: Bureau of Publications, Teachers College, 1921.)

2. "There is a need in the course in general science for definite training in the reading of newspaper articles having scientific content for the purpose,

"a. Of teaching the pupils to read with thought and discrimination tending toward the development of scientific attitudes in reading while seeking entertainment and information;

"b. Of stimulating the pupils to use their general scientific information as a foundation for a broader knowledge leading to greater pleasure in the reading, as well as to possible practical values.

This need is plainly indicated by the fact that

"a. More than half the newspaper articles having scientific content, as revealed by this study, supply *information* which may be of any degree of complexity from very simple to extremely complex and technical; about a fifth furnish advice of a scientific nature, and about 1 out of every 20 gives definite instruction.

"b. About a fifth of the articles are semi-organized, and about a sixth completely and carefully organized discussions of topics and phases of science.

3. "The logical inference from this study is that normally articles upon the biological sciences would be practically as numerous as those upon the physical sciences. This and other facts would seem to indicate that the biological sciences, to which is devoted much less space and which receive much less emphasis than the physical sciences in most of the text-books on general science, are probably entitled to a greater proportionate representation, in so far as the function of providing a serviceable foundation for an intelligent reading of the press is concerned.

4. "Only 5.7 per cent of the articles on the biological sciences require a foundation of technical knowledge as against 24.9 per cent of those on the physical sciences. These latter are, however, mostly upon radio, auto-mechanics, and aeronautics. It is surely desirable that pupils have the opportunity during their courses in general science to acquire this technical information to the extent of their interests and capacities, and since, because of space limitations, it is not possible for the *text-book* on general science to furnish much highly technical information, opportunities for securing this knowledge should be adequately supplied through the medium of extensive reading.

5. "A knowledge of theories and hypotheses is assumed in about 5 per cent of these articles. Twenty-two of the 30 articles involve theories of biological evolution and heredity (16) and of cosmic evolution (6); of the remaining articles, two involve the Einstein theory of Relativity, and another, theories of overtones in sound. Opportunity should therefore be given for gaining a knowledge of at least these two first-named theories. It would seem, moreover, that the recurrence of articles on biological and cosmic evolution in the press should entitle these to at least a brief treatment in text-books on general science; but there should be also abundant opportunities for studying these and perhaps other theories in detail in extensive extra-text reading."

6. "Sound, which receives a generous treatment in many general science text-books, is the topic of only .3 per cent of the articles analyzed in this study. Insect pests, fossils, and various phases of astronomy are represented by practically an equal number of these articles, despite the great economic importance of insect pests."

7. "The evidence of this study would go to show that the scientific terms used by the press which appear also in

The Teacher's Word Book are distributed almost equally among the thousands, the range here being between 4.5 per cent for the first thousand and 2.1 per cent for the sixth, with an average for all the first ten thousands of 3.5 per cent."

"It would seem, therefore, from this study that the addition to the child's reading vocabulary of each thousand of the most frequently occurring words does not add greatly to his equipment for an intelligent reading of science in the public press, and that vocabulary building based upon *The Teacher's Word Book*, does not in itself promise to provide adequately for the needs of pupils in science." "It is possible, too, for a pupil to have gained through training and otherwise, a serviceable familiarity with a term in its commoner meanings without having encountered the word in its scientific connotations. A further difficulty is that a considerable portion of scientific terms are made up of more than one word and owe their scientific connotations to the combinations and not at all to the separate meanings of the component words."

"An effort should be made, therefore, to provide more adequately for the vocabulary training of pupils to insure their ability to read science and think in terms of it more effectively and with more enjoyment."

8. "The [962 different] scientific terms [found in the 630 articles] indicate the enormous range of scientific vocabulary found in the public press and emphasize the need for extensive training in science as a foundation for reading the newspapers."

STUDY NO. 44C

An Investigation of Adults' and Children's Scientific Interests

By Francis D. Curtis*

Problem.—To ascertain some of the scientific interests of adults and of children of the junior high school or early senior high school, to the satisfaction of which interests extensive reading should contribute.

Method.—A letter modeled after that used in Pollock's study of children's interests[1] was given to pupils of general science in six high schools in Oregon, three in New York City, and one in Oklahoma. Below this letter on the same sheet was another addressed to the parents of the pupils, asking both fathers and mothers to write down the scientific topics, theories, or questions which most interested them. Attached to the letter was a sheet giving examples of questions at the top and having below, numbered spaces for the questions by the pupil, the father, and the mother.

The 3330 questions and statements received from pupils and the 3232 from adults were all given three separate analyses:

In the first, the interests indicated were divided into two classifications, Physical and Biological.

In the second analysis, the nature of the information desired in each question was determined:

1. Those which asked for a definition, as "What is light?" "Of what is glass composed?"

* Doctor's thesis. *Some Values Derived from Extensive Reading of General Science*, Contributions to Education, No. 163. New York: Teachers College, Columbia University, 1924. pp. 27–40.

[1] Study No. 32C.

2. Those which ask for information of a general nature, as "What causes the tides?" "Why doesn't an iron ship sink when it is in the water?"

3. Those which ask for definite technical information, as "What is the proper way to graft trees?" "How is copper extracted from rock?"

4. Those inquiring definitely about some scientific theory. None was included in this classification unless it was obvious from the question that the inquirer had at least some slight acquaintance with a recognized theory.

In the third analysis, every question and statement was studied carefully in an effort to determine accurately the real subject or interest revealed by the statement or question. These interests were defined as specifically as possible; the effort was made to avoid wherever possible such general terms as "botany," "light," etc., in favor of more definite terms, as "photosynthesis," "images," etc. For example, "Why do plants turn toward the sunlight?" was listed under "heliotropism;" "Why does a yard-stick, when placed in water, appear bent?" was listed under "refraction." All questions involving radio, however, were listed under that term. A few questions not clearly related to the physical or biological sciences were disregarded; for example, "What is our first duty?" "Why are poor women nervous wrecks these days?" A few others not scientific though "pseudo-scientific," were included, as "How do the stars influence life?" "What is the truth about spiritualism?" since it was considered that in a study of this sort, interests in topics not at present considered scientific, are quite as valuable as those involving accepted facts.

Findings.—(1) "The boys are much more interested in technical processes than the girls, and the men than the women. This interest in technical processes apparently

grows as individuals get older, since the percentage average for adults is in this study about three times that for the high school pupils."

2. "The boys are apparently more interested in the better-known theories than the girls, as indicated by 44.4 per cent more questions about theories, and the men than the women, as indicated by 50 per cent more questions. This interest in theories apparently grows appreciably with the boys as they mature, but not with the girls."

3. In so far as technical processes and theories "may represent upper levels in a hierarchy of scientific interests, the interests of these girls and women are more superficial than those of these boys and men."

4. "These boys and these women showed more interest (measured by numbers of times of appearance) in theories than in technical processes; and these girls very much more, since in this study the latter showed practically no interest in technical processes whatever. But the men showed a much greater interest in technical problems and processes than in scientific theories."

5. "This study shows a very much greater interest among these pupils and adults [living in *cities and good-sized towns*] in the physical than in the biological sciences, measured both by number of questions and by number of interests." "The results of the investigator's study of newspaper articles[1] are, moreover, considerably at variance with the results of this study in this respect.

6. ". . . there is indicated in this study a considerable shift of interest toward the biological sciences and away from the physical with both sexes between early adolescence and mature adulthood; measured by numbers of questions the average percentage increase of the biological sciences for

[1] Study No. 43C.

the men and women over the boys and girls is 38.3 per cent and measured by numbers of interests it is 7.4 per cent."

7. ". . . the range of interest with the girls was found to be 12.4 per cent greater than that with the boys." "The agreement between Pollock's and the investigator's findings in this respect is therefore very close."

8. "The results of this study would seem to indicate that the range of interest with the men is practically equal to that of the women, with a slightly greater range with the men."

9. ". . . the scientific interests of one sex not shared by the other are characteristic, being largely physical for boys and men, and biological for girls and women."

TABLE XVIII

SCIENTIFIC INTERESTS AS REVEALED BY QUESTIONS (CURTIS STUDY)

	Boys	Girls	Men	Women
Number of questions.....	1488	1842	1495	1737
Number of different interests[1].	312	350	450	443

[1] Interests of boys not shared by girls, 112.
Interests of girls not shared by boys, 152.
Interests of men not shared by women, 214.
Interests of women not shared by men, 207.

10. ". . . in Pollock's study 5 of the first 10 interests, in order of frequency, are phases of astronomy, and other topics ordinarily treated in elementary text-books on astronomy are found further down the list; these same 5 interests in the same order are found in the first 13 interests of the boys and girls combined, in this study. That this interest in astronomy [greater than that in any other general subject indicated by these studies] is a 'life interest' is shown in this study at least, by the fact that these same 5

Table XIX

Rank and Frequency of the 49 Most Important Scientific Interests of Children, as Indicated by Frequency of Appearance (Curtis Study)

Rank	Frequency	Interest	Rank	Frequency	Interest
1	194	Stars	26.5	30	Snakes
2	106	Electricity	26.5	30	Solar system
3	95	Animals	28.5	29	Aurora borealis
4	94	Planets	28.5	29	Hibernation
5	91	Moon	30.5	28	Rain
6	89	Earth	30.5	28	Thunder
7	81	Gravity	33	27	Geysers
8	79	Earthquakes	33	27	Tides
9	75	Volcanoes	33	27	Trees
10	69	Sun	35	26	Sound
11	67	Radio	36.5	23	Birds
12	57	Smoke	36.5	23	Hair
13	54	Mars	38	22	Evolution (cosmic)
14	51	Lightning	39.5	21	Eclipses
15	46	Flowers	39.5	21	Mechanics
16	43	Ocean	42	20	Gases
17	42	Plants	42	20	Germs
18	36	Air	42	20	Sky
19	35	Light	44	19	Combustion
20.5	33	Fish	47	18	Comets
20.5	33	Wind	47	18	Geology
23.5	31	Astronomy	47	18	History of science
23.5	31	Clouds	47	18	Rainbows
23.5	31	Crude-oil	47	18	Snow
23.5	31	Meteors			

TABLE XX

RANK AND FREQUENCY OF THE 47 MOST IMPORTANT SCIENTIFIC INTERESTS OF MEN AND WOMEN, AS INDICATED BY FREQUENCY OF APPEARANCE (CURTIS STUDY)

Rank	Frequency	Interest	Rank	Frequency	Interest
1	90	Radio	22.5	29	Sound
2	74	Stars	25	27	Planets
3	54	Electricity	27	25	Diet
4	48	Crude-oil	27	25	Gardening
5	47	The earth	27	25	Wind
6	43	Moon	29.5	24	Light
7	40	Animals	29.5	24	Lightning
8.5	39	Flowers	32	23	Chemistry (household)
8.5	39	Volcanoes			
10.5	38	Sun	32	23	Meteors
10.5	38	Tides	32	23	Snakes
12	37	Earthquakes	34	22	Clouds
13	36	Psychology	36	21	Automobile mechanics
14.5	35	Evolution (biological)	36	21	Radium
14.5	35	Fish	36	21	Trees
16	33	Gravity	38	20	Birds
17.5	32	Ocean	39	18	Physiology
17.5	32	Plants	40.5	17	Geology
19	31	History of science	40.5	17	Rain
			42	16	Stain removal
20	30	Mars	44.5	15	Coal
22.5	29	Air	44.5	15	Geysers
22.5	29	Astronomy	44.5	15	Seasons
22.5	29	Solar system	44.5	15	Thunder

TABLE XXI

RELATIVE RANKS OF THE 37 TERMS WHICH APPEAR IN BOTH CHILDREN'S AND MEN'S AND WOMEN'S (COMBINED) LISTS OF SCIENTIFIC INTERESTS (CURTIS STUDY)

Rank, children's	Rank, adults'	Interests	Rank, children's	Rank, adults'	Interests
1	2	Stars	20.5	14.5	Fish
2	3	Electricity	20.5	27	Wind
3	7	Animals	23.5	22.5	Astronomy (misc.)
4	25	Planets			
5	6	Moon	23.5	34	Clouds
6	5	The earth	23.5	4	Crude-oil
7	16	Gravity	23.5	32	Meteors
8	12	Earthquakes	26.5	32	Snakes
9	8.5	Volcanoes	26.5	22.5	Solar system
10	10.5	Sun	30.5	40.5	Rain
11	1	Radio	30.5	44.5	Thunder
12	49	Smoke	33	44.5	Geysers
13	20	Mars	33	10.5	Tides
14	29.5	Lightning	33	36	Trees
15	8.5	Flowers	35	22.5	Sound
16	17.5	Ocean	36	14.5	Evolution (biol.)
17	17.5	Plants	39	38	Birds
18	22.5	Air	48	40.5	Geology
19	29.5	Light	48	19	History of science

interests, along with other closely allied ones, are among the first 26 of adult interests."

11. "It should prove of interest to makers of text-books and tests on general science that there was found to be a correlation of $.69 \pm .04$ between the ratings (determined by frequency of occurrence) of the 96 terms common to both Pollock's and the investigator's lists of boys' and girls' (combined) interests."

12. "In the investigator's study 36 of the most frequently occurring scientific interests of the boys and girls combined, occur among the 47 most frequently occurring scientific interests of the men and women combined. The rankings of these interests in the two lists (as indicated by frequency of occurrence), moreover, for the most part closely agree. Makers of text-books and tests should find [in Tables XIX, XX and XXI] valuable information for their purposes."

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